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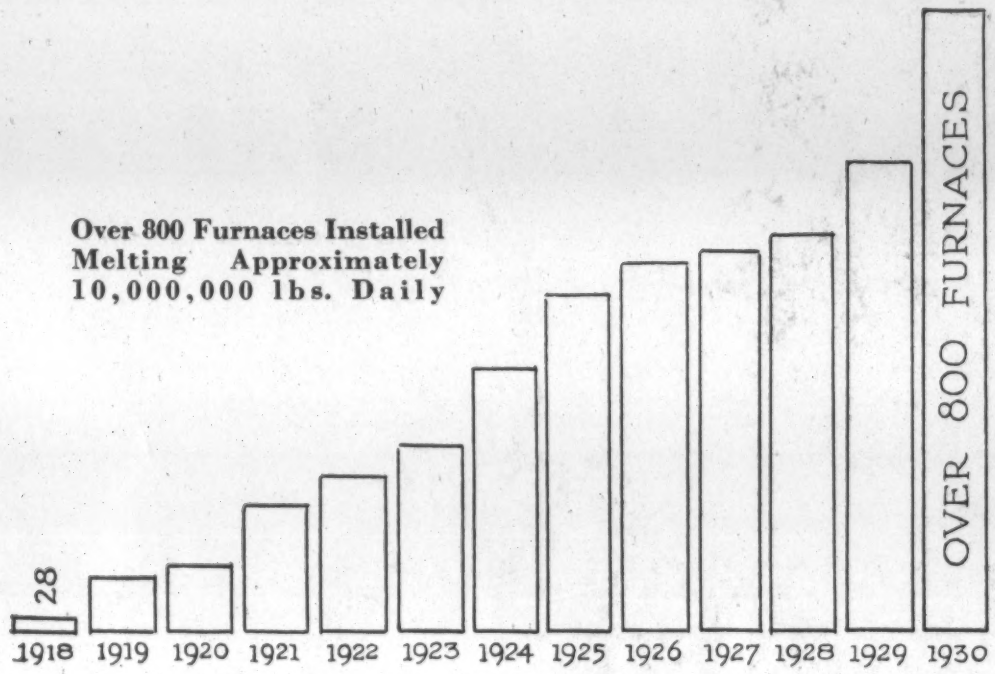

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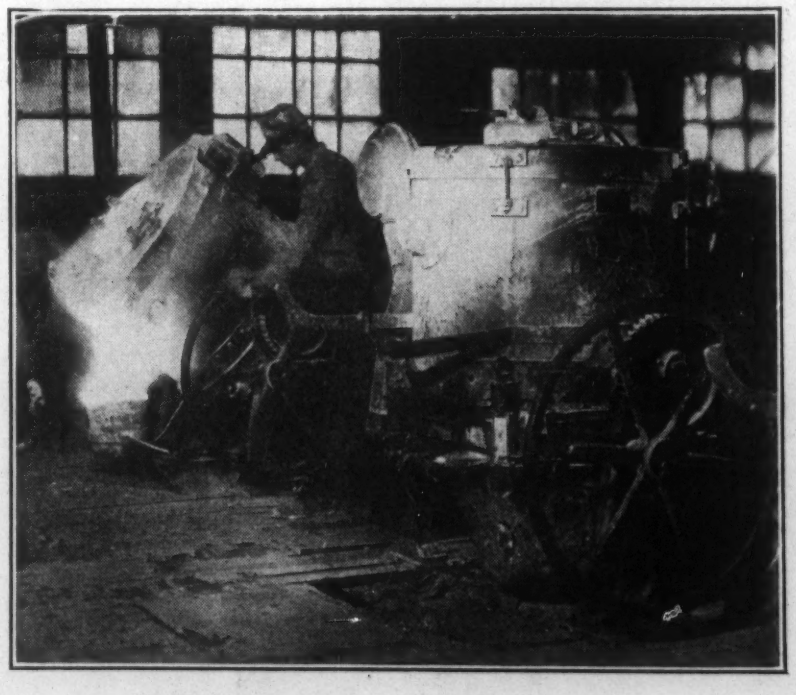

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# PUBLISHER'S PAGE

*Note—On this page the publishers will talk right straight to you each month. We will tell you how things are progressing with* METALS & ALLOYS. *We will undoubtedly ask your advice on many points. We are publishing this paper not primarily to please ourselves but rather to serve you. And our office door is always open. You are invited to call.*

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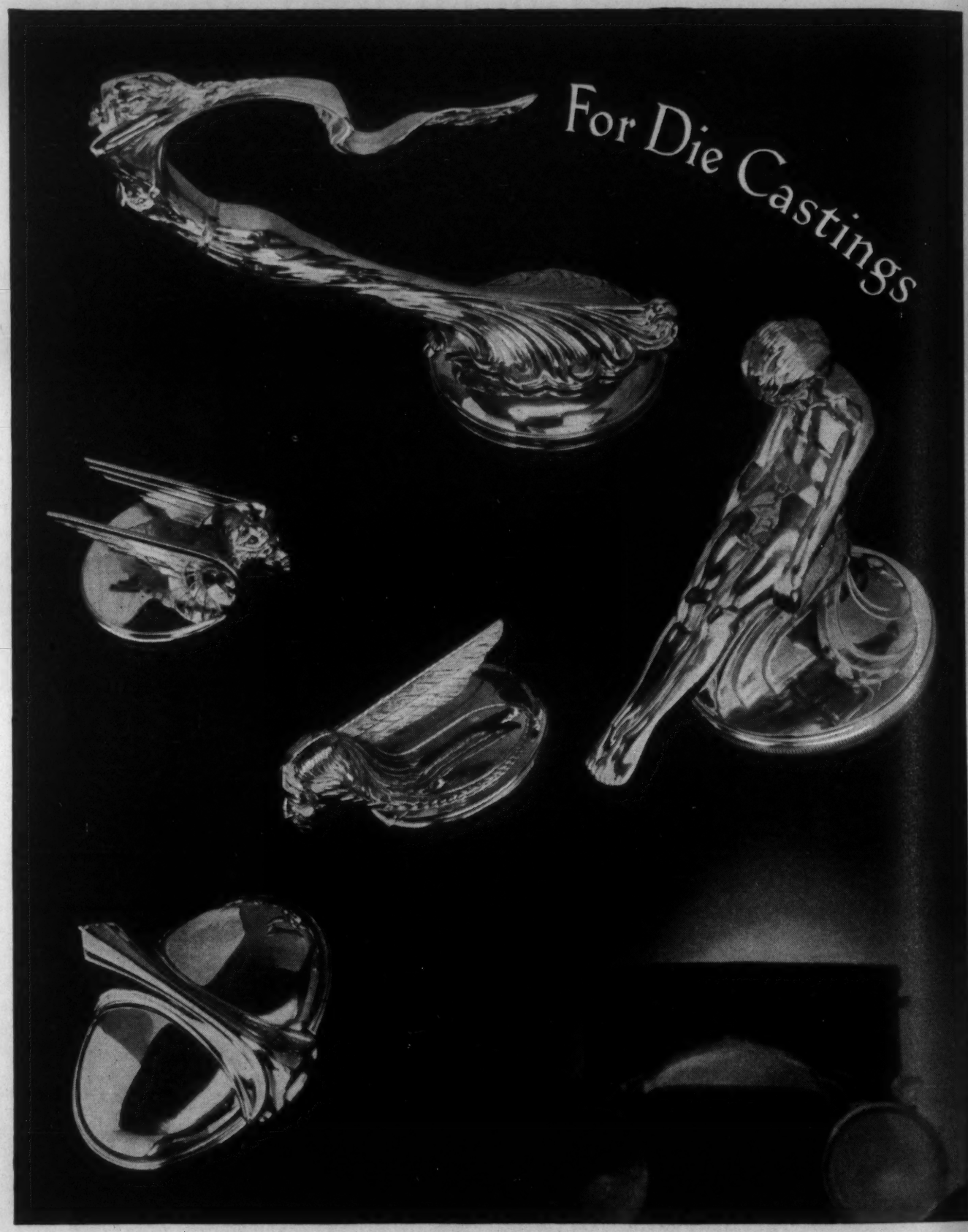


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# Editorial Comment

*In this department I try to comment on metallurgical and allied matters that seem to me interesting and significant. The views expressed reflect my own personal attitude. Many of our readers will have ideas of their own on these subjects and are urged to contribute them in the form of letters which will gladly be published in succeeding issues.*—H. W. GILLETT, *Editorial Director*

## Eighteen and Eight

Before long it will be necessary for metallurgical schools to establish special courses in, and professorships for, the study of austenitic steels. There is now a voluminous literature of the subject, but the more use is made of such steels the more details crop up to be clarified.

Many special problems come up in the manufacture and use of the austenitic steels that are quite different from those met in the better-known alloy steels. The old standby—Hadfield manganese steel—whose metallurgy sounds so simple, on the assumption that it is a single-phase system under all conditions except high pressures when it becomes martensitic, is, according to Hall[1] and Krivobok[2], not so simple after all. The advent of tungsten carbide tools and the consequent extension of machinability of such a steel, bring it more prominently to attention.

The peculiar properties of the austenitic nickel steels such as Invar, Permalloy and the like, and the oddities of the meteoric Fe-Ni alloys indicate at even a casual glance that there is much more to be known and understood about that series of alloys.

But it is the chromium-containing series of austenitic steels that holds the center of the stage at the moment. The rusting of ordinary carbon and alloy steels produces such woeful waste that corrosion-resistance has been for decades a major topic for metallurgical discussion.

High-chromium steels afford the obvious way out. First of all came stainless steel. Every housewife had stainless steel paring knives and every husband could see how nice it is to have a really rust-resistant steel. But stainless steel is only stainless under proper heat treatment. The presence of high chromium forces back the eutectoid composition so that a 0.20% C stainless is really a high carbon steel. Low carbon ferro-chromium had to become commercial for the next step. When it did, stainless iron appeared, with more foolproofness as to stainlessness and greater latitude as to formability.

Myriads of processes for making stainless iron then came along and the patent situation messed everything up, but the desirability of making all kinds of products out of a stain-resisting alloy became more and more implanted in the public mind. Chromium-plating of automobile parts then came into vogue, since Duco finishes made the body retain its luster so long that the readily-dulled nickel plating became crummy-looking very soon and something better had to be found.

But chromium-plating was like the little girl with the curl in the middle of her forehead, when it was good, it was very, very good, but when it was bad, it was horrid. And to make it good cost money and slowed up production.

Then came the Ford hub-cap, made from 18% Cr 8% Ni steel, an alloy that had been developing under a variety of trade names and designations of letter-and-number symbols about as numerous as the brands of 5 cent cigars. When people heard that Ford was using 18–8 they ceased to be worried about the high initial cost of the alloy for they had definite evidence that the over-all cost was low. Like sheep following the bell-wether, makers of things that ought to be rust-resisting began to look into 18–8.

Meanwhile the resistance to oxidation and to attack by sulphur of the high chromium alloys had brought them to the attention of oil-refiners, especially for cracking processes. Turbine builders, and the power-plant industry in general, needed alloys resistant to high temperatures and to high pressures as well. Heat-treatment furnaces began to become instruments of precision for automatic production methods instead of piles of brick run by the "man at the fire," and required alloys of good strength at high temperatures. Automotive valves offered many problems. Nitrogen-fixation and other chemical industries demanded high temperature alloys. Straight chemical corrosion problems demanded tanks and piping from alloys of superior corrosion resistance.

The attention of metallurgists was thus most forcibly drawn to the high chromium alloys in respect not only to strength and corrosion resistance at ordinary temperatures but also to high temperature properties and to formability, weldability, uniformity and ease of production. With, say, 10–30% chromium as the basis, the effect of carbon, silicon, copper, nickel, manganese, tungsten, molybdenum, cobalt, etc. began to be studied. So-called "stable surface" steels with silicon additions were advocated, and copper additions were used as well.

For many of the purposes for which steels of exceptional properties were required, the 18% Cr 8% Ni austenitic steel came into favor and to-day is of the greatest importance. Its corrosion resistance does not leave much to be desired. Its modulus of elasticity is a bit low but its impact resistance is extremely high. It has a high coefficient of expansion. Its strength in its most corrosion-resistant condition, quenched from about 2000° F., is not very high but it has great ductility. It is extremely tough stuff, and will stand much deformation in cold working. It hardens up rapidly on cold work, which is an advantage for some uses but a difficulty when extreme deep-drawing is to be performed.

It has respectable strength at high temperatures, but tends to become brittle under some conditions of high-temperature service. Both ferrite and carbide precipitation may occur and it doesn't stay wholly austenitic under all circumstances. Its instability is not as well understood or as controllable as it will be later. Carbon content is important and the need for very low carbon ferro chromium as well as for a considerable amount of expensive nickel makes it costly.

Interesting developments are occurring in the effort to cope with the idiosyncracies of the austenitic type of alloy. The International Nickel Co.[3] advocates the use of 14% nickel instead of 8%, claiming that this composition puts the alloy in the stable austenitic range, makes it harden up less on deep-drawing, and allows it to tolerate more carbon so that it is not so necessary to strain every nerve to keep the carbon down. The cost of the extra nickel is said to be compensated for by the ability to use higher carbon ferro-chromium, though this seems a bit doubtful.

The Electro Metallurgical Co.[4] is working in the other direction, avoiding use of nickel and replacing it by manganese. It is, of course, well known that manganese is even more potent than nickel in producing austenite and it is very logical to study such a substitution. The 18% Cr 8% Mn alloy, while not as corrosion-resistant under all conditions as its cousin 18% Cr 8% Ni, is naturally more resistant to sulphur attack, to which nickel is prone. The manganese-containing alloy is claimed to be free from high-temperature embrittlement which is, so far, one of the weak points of the nickel-containing alloy.

The Cr-Mn alloy has obvious advantages in ease of pro-

[1] Hall, J. H. Studies of Hadfield's Manganese Steel with the High Power Microscope. *Transactions American Institute Mining & Metallurgical Engineers*, Vol. 77 (1929), pages 382–427.

[2] Krivobok, V. A Study on the Constitution of High Manganese Steels. *Transactions American Society for Steel Treating*, Vol. 15 (1929), pages 893–951.

[3] Pilling, N. B. Some Effects of Nickel Content in Austenitic Iron-Chromium-Nickel Alloys. *Preprint* No. 36, for June 1930 Meeting, *American Society for Testing Materials*, 13 pages.

[4] Becket, F. M. Chromium-Manganese Steels. *Preprint* for May 1930 Meeting, *American Iron and Steel Institute*, 13 pages.

duction so as to be relatively free from non-metallic inclusions, as that goes with a high Mn-content. It works and welds well. Oddly enough, it is not wholly austenitic at very low carbon contents even though Mn is supposed to be more effective in producing austenite than Ni is.

There is argument as to the adaptability of the Cr-Mn for extreme deep-drawing as its rate of hardening is thought by some to be greater than that of the extra-high Ni alloy, though direct comparisons are lacking. The relative cost is also in dispute, since the Cr-Mn alloy will require both low-carbon ferro-chromium and low-carbon ferro-manganese.

While no great hullabaloo has been raised about the Cr-Mn alloy, it is being taken more seriously than the small amount of information printed about it would indicate. Whether they prognosticate correctly or not, the owners of domestic manganese deposits figure that with the tariff and with a new potential market for Mn in austenitic steels, things are looking up.

It will be interesting to sit on the side-lines and view the Ni-Mn struggle. As a rule such struggles end with a score on both sides. It is usually possible to blend alloying elements so as to obtain an optimum result with much of the good qualities of each and a minimum of the drawbacks. Hence, we look forward to a C-Cr-Ni-Mn austenitic alloy steel, probably with doses of Si, Cu, W, Mo, Co, etc. for special purposes.

By the time all the details are worked out there will have been need for many more exhaustive investigations—sufficient to supply topics for doctor's thesis to many students in our hypothetical graduate school, seeking the degree of D. A. M.—Doctor of Austenitic Metallurgy.

## Le Chatelier's Principle

There is a fundamental law of physical chemistry, the principle of Le Chatelier, which underlies the phase rule and the equilibrium diagrams of the chemist and metallurgist.

This can be stated as follows: If an external restraint is placed upon a system, that reaction tends to take place which will oppose that restraint. Every change in a factor of equilibrium tends to produce a transformation in the system which will change the factor in question in the opposite direction.

Resistance to external restraint is not limited to inanimate systems. It extends to the body politic and to the individual. The Boston tea-party, prohibition and compulsory chapel are cases in hand.

Our own idea of a vacation is a period in which one can do just as he likes without direct or indirect restraint from anyone. Most restraint is indirect; one has to do certain things at certain times, either to avoid discommoding others or because of what others will think. When one can shave only when the whiskers become a nuisance to their owner, when he can eat and sleep and go and come with no reference to the wishes of others, then only is a vacation 100%.

Of course, it is only on a vacation that it is possible to be free from restraint, and restraints are necessary. But the inevitable reaction that tends to oppose the restraint is too often forgotten. We know some research groups that punch the time-clock like any workman. Exceptional men in those groups do not particularly mind this, but most men react, consciously or unconsciously, against it, and tend to confine their interests in their work to working hours. In groups where no such restraint exists, we think the management gets more actual work and far greater interest.

A wider understanding of the principle of Le Chatelier and an appreciation that metallurgists, as well as metals, behave in conformity with it, would result in fewer restraining rules laid down by the management and more traditions voluntarily built up by the workers. A rule creates a tendency for evasion of it, while a tradition creates a tendency toward compliance with it.

## Some Metal Congress Thoughts

The Annual Metal Congress and Exposition has become an institution—we cannot do without it. One needs to rest up after it is over, but it is a whole lot better than the separate conventions it replaces. It saves time and travel, brings together all phases of the metal industry and gives a complete picture of the advances in metallurgical engineering.

No one can be in enough places at one time to see all the exhibits, hear all the papers, take all the plant trips and talk with all his friends that he would like to, but he can select whatever combination most appeals to him. More is adsorbed from a concentrated solution than from a dilute one, and we believe anyone who attended the Chicago Congress adsorbed enough to repay him and his firm for the expense.

It is scarcely necessary to comment on the meetings themselves, as the papers will be duly abstracted in our abstract section. But mention must be made of the wonderful clarity of Dr. Grossman's Campbell lecture and of the universal satisfaction at the award of the Howe medal to Mr. French. Both honors were well deserved.

What one hears in the lobbies is as interesting as what one hears in the meetings or sees in the exhibits. While the lobby comment largely referred to the weather (which was quite equivalent to a Turkish bath and is one thing Bill Eisenman cannot schedule), and to the lessons in geography necessary to find the exhibit one wished to reach, there were other comments as well. For example, the advantage of close coöperation between ferrous and non-ferrous metallurgists was spoken of by many. Dr. Jeffries as usual hit the nail on the head when, at the joint Iron and Steel Division and Institute of Metals dinner, he pointed out the increasing haziness of the dividing line between the two fields.

Of the 85 subjects considered by the Steel Treaters, Mining & Metallurgical Engineers, Welding Society, Mechanical Engineers and Railroad Master Blacksmiths a large proportion were of equal interest to both ferrous and non-ferrous men and the advantage of simultaneous conventions was very obvious. It is to be regretted that the meeting of the American Electrochemical Society overlapped the Congress.

An interesting symposium on corrosion was going on in Detroit on the same day as the session on corrosion-resistant chromium and nickel-chromium alloys at Chicago, and many who would have liked to listen to both had to cut one or the other. On the next day there were nitriding and carburizing sessions at Chicago and a round-table on cast iron at Detroit. The conflict there was not so obvious as in the case of corrosion but there are so many engineers interested in more than one material of construction that it was a conflict none the less. It is hoped that the Electrochemists will meet with the next Metal Congress.

Not only the quality of modern research but its appreciation came in for comment. Directors of research for corporation after corporation said that despite business depression, their research staffs were being retained. Few firms have yet gotten to the point where they take advantage of a lull in production to mend their fences by increased research activity, but most of them have learned that it is folly to disrupt a going research group. The reason for this was brought out by a comment made to us that a certain great industry was very low on tonnage production but was being kept in quite fair shape by activity in various specialities and quality products that had resulted from the work of the research staff. The chief engineer of one corporation, which classes as a new metallurgical giant, rather startled us by saying that they prided themselves on thinking as much of, and treating as well, their production and design engineering staff as they did their research staff, even though it was easier to find competent engineers than competent research men. Many research men feel that their firms still look upon them as a new-fangled type of arrival whose real value is not appreciated. This man was sure that the modern executive appreciates that his research staff is the cornerstone of present and future business. Indeed, he was somewhat apprehensive whether the supply of research metallurgists was being adequately maintained. Unless it is, there will come a time when the Metal Congress does not portray as vast strides as the recent ones have done.

# Source of Heat for Heat Treatment

By Robert M. Keeney*

The source of heat for heat treatment influences quality production at a low over-all cost of finished product, but does not determine either the quality or the over-all cost. The quality and over-all cost of the finished product are determined by skilled metallurgical supervision of the operation of the correct form of furnace heated by the source of heat best adapted to the form of furnace and to the process, with due consideration given to the relative heat costs of the sources of heat available and to the quality of product desired. Just as quality and cost must often compromise, so must form of furnace and source of heat compromise in some situations. Neither can be selected safely without consideration of the other.

It is natural that B. t. u. cost should first enter the mind of one deciding the source of heat, because it is the only item of cost quickly at hand without much careful investigation. Consideration must also be given to its preparation for utilization, efficiency of utilization and application to the process and to the form of furnace which seems best to fit the manufacturing requirements of the plant. A source of heat may have such a high "form value" when applied to the form of furnace most suitable for the heat treating operation that it is used regardless of its B. t. u. cost, or, in some localities, a source of heat of low "form value" may have so low a B. t. u. cost that, regardless of difficulties in its use, the over-all economic situation dictates its use, even to the sacrificing of quality.

Quality must be evaluated in terms of marketability and competition, or in terms of loss of market and increased costs due to a high percentage of rejections. Rejections due to poor quality may not be so very costly on a product not subject to many manufacturing operations, but may prove to be very expensive toward the end of a procedure involving many steps with much time and labor expended on the product. Rejections due to poor heat treatment would cause a marked increase in the over-all cost of the finished product. When viewed from the broad angle of the ever increasing demands of modern civilization on the products of industry and from the competitive market situation, temporarily high costs might well prevail in the interests of improved quality. It is always well to be a step ahead, for as Henry Ford[1] states: "A manufacturing company is only as good as its product, and, unless the product be constantly improved, it will not constantly draw the public to its buying.....First-class goods and commodities can always be sold.....at a price."

The following sources of heat are available for heat treatment—solid, liquid, liquified gaseous and gaseous fuels and electricity, stated in accordance with their general "form value." Of the solid fuels, wood is no longer used except for the finishing annealing of brass in one section of the country. Because of its high cost and lack of "form value," few heat treating furnaces are fired with anthracite coal. The number of furnaces heated by burning bituminous coal and coke on grates is rapidly decreasing because of the great skill required, not only in design of furnaces, but also in firing, if uniform heating is to result. Powdered coal is economically applicable only to large operations where there is a large divisor for the heavy investment charge, and to the more crude heat treating processes, in which deposition of ashes on the work is not objectionable. Of the liquid sources of heat, the heat treater is mainly concerned with fuel oil. The more recently available liquified gas or butane—with some of the disadvantages of oil and some of the advantages of gas—offers interesting possibilities under suitable local economic conditions.

* The Connecticut Light and Power Company, Hartford, Conn.

[1] Henry Ford & Samuel Crowther. The Fear of Overproduction. *The Saturday Evening Post*, July 12, 1930.

Of the gaseous fuels, there are available natural gas, manufactured or city gas and mixed gas, a mixture of natural gas and manufactured gas. City gas is also usually a mixture of two or more manufactured gases. A few industrial plants make their own gas for heat treating—clean producer gas, blue water gas, or oil gas, but the production of any of these gases requires a comparatively expensive installation, on which as great a return usually cannot be earned as by a similar investment in its own manufacturing operations. It is not at all the same situation as private plant generation of sufficient power to meet steam requirements, where power becomes a by-product of steam. The remaining source of heat is electricity, which occupies its present position in heating for heat treatment because of its "form value." The sources of heat which survive the accurate heat treating requirements of modern industry are the liquid, liquified gaseous and gaseous fuels and electricity—all of comparatively high "form value" and all of higher B. t. u. cost than the solid fuels in most localities. "Form value" is of great importance in the selection of the source of heat for heat treatment.

## Preparation for Utilization

As the "form value" of the source of heat increases, the amount of preparation necessary for its satisfactory utilization tends to decrease. Difficulties of utilization also decrease. Depending somewhat on the size and skill of the operating organization and the character of the process, the elimination of the preparation and difficulties may or may not be of value in lowering over-all costs. It is obviously of less value to the large tonnage producer, which, because of the nature of its business, must maintain a large engineering organization to plan operations, than to the specialty manufacturer, large in its line, but not large enough to warrant the support of a skilled engineering staff experienced in all branches of manufacturing. However, even skilled engineering organizations often find that some heat treating operations in their plant are ultimately best solved by the use of sources of heat of high "form value."

For the utilization of oil the following auxiliary equipment[2] has been found to be necessary or at least desirable:

(1) Water or rail transportation facilities adjacent to the manufacturing site.

(2) Storage tanks of sufficient size to hold a comparatively large quantity of oil, so that a change in the specific gravity or composition of the oil will have little effect on the character of the oil as burned, and to avoid a shut down in case of interference in transportation.

(3) Steam coils in the storage tanks to keep the oil warm enough to pump easily.

(4) An unloading pump.

(5) Easily cleaned double strainers for straining the oil after it leaves the storage tank.

(6) An oil circulating pump equipped with relief valve, air chamber and gage.

(7) An oil heater between the pump and the burner.

(8) A source of air or steam.

(9) Piping system for distribution of oil and air or steam.

(10) Flues for removal of the products of combustion from the furnace, and a well planned ventilating system for the heat treating room.

Successful utilization of oil depends to a large extent upon building up its "form value," by careful operation of a complete and well designed auxiliary equipment, in order to deliver clean oil to the burners at a uniform pressure and viscosity. Fluctuating oil pressure makes impossible the maintenance of

[2] M. H. Mawhinney. Oil Burning Equipment for Industrial Furnaces. *Transactions American Society for Steel Treating*, Vol. 9, Jan. 1926, page 99.

steady combustion. Strainers must be kept clean or the burners become clogged. If the oil becomes too cold, poor atomization is obtained, and incomplete combustion results. If the character of the oil changes, a general re-adjustment of the auxiliary equipment and burners must be made. Running with a deficiency of air will result in soot deposition and poor working conditions, if the ventilation system is not well designed and carefully maintained. Un-insulated furnaces, of course, mean a hot heat treating room.

**Utilization of Butane[3] Involves:**

(1) Rail transportation facilities adjacent to the manufacturing site.

(2) Pressure storage tanks of sufficient size to hold a comparatively large quantity of butane, in order to avoid a shut down in case of interference in transportation.

(3) Unloading facilities consisting either of pumps, or a source of compressed air.

(4) Strainers.

(5) A liquid regulator, reducing the pressure of the liquid to about 5 lb.

(6) A vaporizer in which the latent heat of vaporization is supplied by steam or warm water or hot oil and the pressure reduced to accomplish vaporization.

(7) A gas regulator reducing the pressure from 5 lb. to that desired in the plant.

(8) A compressed air supply for the burners.

(9) A piping system for distribution of gas and air.

(10) Flues for removal of the products of combustion from the furnace, and a well-planned ventilating system for the heat treating room.

Although butane is stored as a liquid under its own vapor pressure, it is distributed about the plant and burned as a gas with flame characteristics very similar to natural[4] gas. It is uniform in composition, but requires carefully planned and well maintained auxiliary equipment for its successful utilization. Due to the high B. t. u. content of the gas, 3200 B. t. u. per cubic foot, small distribution mains may be used. Up to the vaporizer, it is handled as a highly refined liquid fuel, and after the vaporizer as natural gas. Gas pressure must be maintained constant to insure proper combustion. Butane gas is odorless and poisonous, and has a specific gravity of 1.95; it is heavier than air. The addition of an odor has been found desirable to give warning of leaks and thus prevent fatal accidents. Being heavier than air, it seeks the ground. Just as with gas, the working conditions of the heat treating room may be good or bad depending upon the system for removal of products of combustion, and upon the insulation of the furnaces.

An industrial plant burning natural gas or city gas in quantity usually requires the following auxiliary equipment:

(1) A piping system for distribution of gas and air to the furnaces.

(2) A means of compressing either gas or air.

(3) Flues for removal of the products of combustion from the furnace, and a well-planned ventilating system for the heat treating room.

[3] C. Longenecker. Butane Burned in Heat Treating Furnace. *Heat Treating & Forging*, Jan. 1930, page 100.
[4] G. R. Benz & E. G. Howick. Butane and Its Combustion. *Heat Treating & Forging*, Mar. 1930, page 371.

Public utility gas, whether manufactured, mixed or natural gas, is maintained at a constant B. t. u. content, at a constant pressure, at a constant specific gravity and is in general of uniform composition. This situation prevails not because of any requirements imposed by law, but because it is of advantage to the public utility in the conduct of its business. Constant B. t. u. content, constant pressure, and constant specific gravity result in satisfied customers and new business.

Any marked change in specific gravity involves adjustment of all domestic, commercial and industrial burners, a costly procedure for the gas company. Without question, public utility gas is the industrial fuel of highest "form value." No public utility business has ever equalled the record of uninterrupted service of the gas companies. As with oil and butane, there is a slight hazard in lighting a gas fired furnace, and the products of combustion must be removed by a ventilating system, but soot does not deposit when operating with a deficiency of air.

The use of electricity as the source of heat requires the following auxiliary equipment:

(1) A distribution line from the sub-station of the industrial plant to the furnace.

(2) In some cases a furnace transformer, depending on the distribution voltage of the power company and on the practice of the furnace manufacturers in design of the furnace.

Heating of the electric furnace is started or stopped by pressing a button, with voltage the only variable, which can affect the rate of heating from day to day. Voltage is maintained with fairly close limits by most power companies even on so-called unregulated service. But as voltage variation materially affects the rate of release of heat in the furnace, the voltage regulation at the plant where electric heating is under consideration should be investigated, before entering into the use of electric heating on a large scale. The voltage regulation of a system as a whole may be good, but that of individual distribution lines may be poor, because of their being overloaded. Electric service is sometimes interrupted, especially in localities subject to thunder-storms. Failure of electric heating elements can no longer be considered as a difficulty, any more likely to be encountered than a refractory failure in a combustion furnace. Five years is not an unusual life for electric heating elements on some heat treating operations. Electricity with its B. t. u. cost usually higher than that of other sources of heat has proven to have such a high "form value" for many heat treating applications, that lower overall costs have resulted than were obtainable with fuels of lower B. t. u. cost.

## Efficiency of Utilization

Heat cost depends upon the price and quantity consumed, that is, upon the B. t. u. cost and efficiency of utilization of the source of heat. Efficiency of utilization may be expressed as net or gross. Net efficiency may be defined as the ratio of the heat energy theoretically possible of absorption by a unit weight of the work to be heated—to the average heat input actually made per unit weight over a period of time involving all of the different operations of the heating process. Gross efficiency differs from net in that the unit weight includes not only the work but also any pans or boxes holding the work.

**Table I**
**Efficiency of Utilization of Sources of Heat**

| | Heat Treating Process | Source of Heat | Type of Furnace | Temp., ° F. | % Efficiency Gross | % Efficiency Net |
|---|---|---|---|---|---|---|
| 1. | Annealing nickel silver | Gas, 530 B. t. u. | Pusher | 1350 | 23.7 | 13.6 |
| | " " " | Electricity | " | 1350 | 72.0 | 41.2 |
| 2. | " " " | Gas, 530 B. t. u. | Continuous belt | 1350 | 18.9 | 18.9 |
| | " " " | Electricity | " " | 1350 | 56.9 | 56.9 |
| 3. | Hardening steel | Oil | Box | 1550 | 11.6 | 11.6 |
| | " " | Gas, 530 B. t. u. | " | 1550 | 17.0 | 17.0 |
| | " " | Electricity | " | 1550 | 56.2 | 56.2 |
| 4. | " " | Oil | Continuous conveyor | 1550 | 17.4 | 17.4 |
| | " " | Electricity | " " | 1550 | 56.2 | 56.2 |
| 5. | Carburizing steel | Gas, 530 B. t. u. | Rotary drum | 1690 | | 7.0 |
| | " " | Electricity | " " | 1690 | | 24.0 |
| 6. | Annealing steel | Oil | Car | 1450 | 24.5 | 18.4 |
| | " " | Electricity | " | 1450 | 50.8 | 43.2 |

As defined above, both net and gross efficiency account for heat energy consumed in heating up the furnace from cold, the time of holding at temperature, loss from opening the door, radiation loss, heat carried away by the products of combustion and absorption of heat in the charge and in the walls of the furnace. Radiation loss and stack loss mean little without consideration of both the time element and load characteristics. Net efficiency tells the story of heat cost, not gross efficiency, or radiation loss, or stack loss.

Table I shows the net and gross efficiency of utilization of a number of production heat treating operations using oil, gas and electricity as the sources of heat. Each comparison is from furnaces of the same form applied to the same operation, and all comparisons are on insulated furnaces of modern design. While there are a few variables involved, the results shown are believed to be on a reasonably comparative basis. The gas furnaces in comparisons No. 1 and No. 5 are of about two-thirds the hourly or charge capacity of the electric furnaces. These efficiencies are not, of course, the maximum efficiencies obtainable with any of the sources of heat, but give a general idea of the efficiencies to be expected in the general run of heat treating operations of average size. Oil fired annealing furnaces holding 6000 lbs. of work are operating at a temperature of 1550° F. with a gross efficiency of 33% and a net efficiency of about 17%. An oil fired carburizing[5] furnace of the pusher type of 1100 lbs. gross capacity per hour at a furnace temperature of 1650° F. has a gross efficiency of 33.3% and a net efficiency of 7.1%. A continuous conveyor gas-fired furnace anneals three tons of brass per hour at 1150° F. with a net efficiency of 35%. A box type electric furnace holding 3000 lbs. of brass anneals to a charge temperature of about 1100° F. with a net efficiency of 72%. With regeneration of recuperation higher efficiencies are, of course, obtainable, but for the average heat-treating operation, regeneration and recuperation do not seem to be considered as seriously as a few years ago, probably because of the investment involved, and because of operating difficulties which sometimes occur. However, counter-flow furnaces heated with oil, gas or electricity have worked out well on annealing and carburizing operations.

Where there is more than one gaseous fuel available for heat treating, it should be realized that one gas may be more efficient than another; that is, that the B. t. u. of one gas can do more work than the B. t. u. of another. The heat value per cubic foot of gas is merely a quantity term and has no bearing on quality. The best indication of the relative quality of gaseous fuels is given by the B. t. u. per cubic foot of the products of combustion. The more heat units developed in a cubic foot of products of combustion, the higher the temperature of the flame and the more heat available to perform useful work. The development of a high flame temperature depends also on the speed of combustion, other things being equal, that is, the rate of flame propagation. In considering the substitution of one gaseous fuel for another, the efficiency of utilization of the two gases should be studied, as a B. t. u. of one gas may not be able to accomplish as much as a B. t. u. of another. For example, the substitution of producer[6,7] gas for coal gas for heat treating at 1500° F., theoretically involves the expenditure of about 20% more thermal units than is theoretically necessary with coal gas.

Largely because of the absence of stack loss the net efficiency of utilization of electricity is usually two to three times that of oil or gas, with the margin decreasing the larger the furnace. Small electric furnaces may have almost as high a net efficiency as large electric furnaces. It is evident that heat cost is not B. t. u. cost, but B. t. u. cost corrected for net efficiency of utilization.

[5] A. E. White & E. R. McPherson. An Efficient Carburizing Furnace of the Surface Combustion Type. *Transactions American Society for Steel Treating*, Vol. 10, Dec. 1926, page 941.
[6] N. E. Rambush. Modern Gas Producers. D. Van Nostrand Co., New York (1923), page 514.
[7] C. J. Wright. Combustion. *Chemical & Metallurgical Engineering*, Vol. 29 (1923), page 888.

## Application to Form of Furnace

Successful application of a source of heat to a form of furnace depends largely upon the skill of the furnace engineer. After due consideration has been given to the heat cost of the sources of heat available, other factors which must be investigated are the following:

(1) Cleanliness and working conditions required.
(2) Maintenance expense.
(3) Effect of furnace atmosphere upon quality of product and upon subsequent cleaning and machining.

The standard of cleanliness and working conditions required is determined largely by the location of the furnace in the plant, by the nature of the manufacturing operations in its immediate vicinity and by labor difficulties which may have been experienced due to poor working conditions. Plants laid out on a strictly straight line basis of production, rather than with all heat treating concentrated in one building may find cleanliness and improved working conditions of great importance in some departments and of little importance in others. Few will question the statement that gas is cleaner than oil, and that electricity is cleaner than either gas or oil. Provision is made on properly installed oil and gas fired furnaces for the satisfactory removal of the products of combustion, but the ventilating system must be well designed and maintained. Whether improved working conditions can be capitalized in reduced over-all costs can be determined only by investigation of their local situation by the plant organization not only with view to the effect on the individual furnace operation but also with consideration given to the possibility of increased production which generally results when work is made easier and more pleasant.

Maintenance expense depends largely upon the use of common sense in operation, upon skillful application of the source of heat to the form of furnace, and upon correct application of form of furnace and source of heat to the job, although in some forms of furnaces, a source of heat may appear to result in lower maintenance cost than other sources of heat. Electric furnaces having nickel-chromium resistors have few heating element failures when applied to the temperature range of the more common heat treating operations, from 1450–1750° F. Within this temperature range heating element failures are often due to an attempt to crowd too much electrical energy into too small a space, with the resulting necessity of carrying a high current density on the heating elements. When failures occur, the current density is often found to have exceeded 10 watts per square inch of resistor surface. Above a furnace temperature of 1850° F. excessive maintenance expense may be expected in electric furnaces equipped with nickel-chromium heating elements, although a few furnaces have been built having a satisfactory life of heating element at 1900° F. Above 1850° F. the silicon carbide resistor can be used to advantage. It has been applied very satisfactorily to furnaces designed to heat high speed steel for hardening and to some types of forging furnaces. In the lower temperature range from 1450–1750° F., the nickel-chromium resistor is preferable. In this range of temperature conditions in the electric furnace are considerably different than in the fuel fired furnace. The electric resistor is itself only 100–150° F. above the furnace temperature, so that electricity as a source of heat imposes little strain on the refractory lining of the furnace, and a properly designed furnace, operated with care, will run for years without any indication of deterioration of refractories or of resistors.

In the combustion furnace conditions are different in that, although the temperature required for heat treating is the same, 1450–1750° F., the flame temperature of both oil and gas usually exceeds 3000° F. As a result of the high temperature of the source of heat care must be taken both in design and operation to provide suitable protection for both refractories and work.

The difference between oil and gas in this respect has been

clearly stated by Prof. W. Trinks.[8] "With the gas fuel, the danger of overheating or of non-uniform heating is not as great as it is with oil fuel. It is true that the temperature of the gas flame is also high, but a gas flame has the advantage, (in this case) that it is non-luminous. From experience we know that non-luminous gases radiate heat only about $^1/_4$ or $^1/_5$ as fast as a luminous flame, which in reality is a stream of hot gas with glowing carbon particles. On account of this difference the danger of overheating is not nearly as great with gas as it is with an oil flame. For that reason, gas is usually burned directly in the heating chamber, whereas oil is burned in a separate combustion chamber."

Until recent years the high flame temperature resulting from the combustion of oil and gas tended to retard the development of oil and gas fired continuous furnaces, but to-day by application of the same degree of skill in design and by the use of heat resisting alloys, many types of continuous combustion furnaces have been brought to a stage of development about on a par with that of the electric furnace. It is probable, however, that these heat resisting alloys are subjected to more punishment in the combustion furnace than in the electric furnace.

Any investigation of maintenance costs with different sources of heat, involves individual study of each application, with care taken that no variables enter the problem, such as the comparison of a modern furnace with an obsolete furnace, or of a rotary hearth furnace with a box type furnace or with a salt bath.

Furnace atmosphere is a function of the source of heat. A furnace atmosphere suitable for one metal or alloy may not produce the best results on another. The products of combustion of the fuel fired furnace consist of nitrogen, carbon monoxide, carbon dioxide, water vapor, sulphur as dioxide and higher oxides and at times free air and uncombined carbon. In the combustion furnace an oxidizing or a reducing atmosphere may be obtained. In the electric furnace of the metallic resistor type, the furnace chamber normally contains comparatively inactive air, and will be oxidizing until the 20% of oxygen in the air has been consumed in burning the oil on the work or any other combustible matter present, or in the absence of either, by combination with surface of the work to form oxide. If the furnace is air tight, or has no great infiltration of air, oxidation stops, and the heating proceeds in an atmosphere which tends to be neutral, or reducing if there was oil on the work when loaded.

The research of Guthrie[9] indicates the effect of the individual constituents of furnace atmospheres on steel. Clean straight carbon steel containing 0.9% carbon was heated in each case in a tube furnace to 1500° F., one sample quenched and the other slowly cooled in the atmosphere in which it was heated. The research shows that carbon dioxide alone is a very rapid scaler. Steam is an active scaler but not a decarburizer. Hydrogen alone is an active decarburizer, but does not scale or oxidize the surface. Normal still air alone is an active scaler, but not a decarburizer at 1500° F. Carbon monoxide, methane, illuminants and other hydrocarbons are carburizers, but water vapor in combination with them acts as a deterrent to the carburizing action. In the gas furnace a non-oxidizing, non-decarburizing atmosphere may be best accomplished by adding raw gas independent of the burners.

In practice, with the reasonable certainty of no change in the composition of the gas, a suitable amount of carbon monoxide can be maintained in the furnace atmosphere, at the expense of gas consumption. The same condition may be obtained with oil, but the oil must be prepared properly for utilization, because a very small change in viscosity or temperature will affect the atmosphere of the furnace. Furnace pressure is an important factor in the securing of suitable atmosphere conditions in a combustion furnace, and in the starting up of a new furnace considerable manipulation of air, gas and pressure may be necessary.

From the experiments of Guthrie one might expect a hopeless scaling of steel in the electric furnace, but in practice this condition is not found with properly designed and operated furnaces, and the situation exists of satisfactory hardening and annealing of thousands of tons of steel daily in what is apparently an oxidizing atmosphere. Possibly it is because a large part of the steel hardened is covered with oil on entering the furnace. There is not the constant movement of atmosphere in the electric furnace that exists in the combustion furnace. The combustion of the oil on the work changes the original oxidizing atmosphere to a reducing atmosphere, which tends to stay in the furnace chamber. The furnace tends to build up pressure, and even in a continuous conveyor furnace, clean work is produced with the feed door open most of the time. In this case air can enter only at one end with suitable quenching arrangements at the other. On steels having a tendency to decarburize, it has been prevented by allowing enough air to enter the furnace, to cause slight oxidation.

Much research is being done at the present time in an endeavor to bright anneal non-ferrous metals and alloys—brass copper and nickel silver by control of furnace atmosphere. Atmospheres available are—steam, carbon-monoxide, hydrogen, nitrogen and the more recently proposed Electrolene. In the gas furnace carbon monoxide, hydrogen and nitrogen may be made available either from unburned gas or from purified products of combustion. In the oil furnace the atmosphere may also be controlled, but the factor of sulphur enters the problem, so that on much work the specification of 1% is not low enough and 0.25% is desirable. In comparison with manufactured gas containing 10 grains of sulphur per 100 cu. ft., oil containing 1% sulphur has 20 times the sulphur content of gas per B. t. u., a consideration of importance in the annealing of brass, because of the tendency of zinc to combine with the sulphur in the products of combustion. In annealing brass in the electric furnace, just as in the case of steel, the oxidizing effect of the air in the furnace chamber is not as great as might be expected for several reasons—the oil on the work, the inertness of the atmosphere and the short time the work is at temperature. With dirt on the brass, the surface of the product of the electric furnace is at times not as clean as that of the combustion furnace, but even with close control of the atmosphere of the combustion furnace, there is no practical economic method available for bright annealing of brass.

For many years steam has been used to produce a so-called bright anneal of non-ferrous metals in water-sealed furnaces fired with oil, gas or electricity. It produces a non-oxidizing and for many applications a satisfactory bright anneal on clean copper, but on brass and nickel silver, while the work is not oxidized, it is water stained, and may require a weak pickle. For nickel silver annealing, in many applications, it results in a saving in comparison with open annealing, because of much lower cost of cleaning.

While the use of hydrogen results in a bright anneal of nickel silver and copper, on brass the results are not satisfactory. Hydrogen or other strongly reducing gases are applicable only to the bright annealing of deoxidized copper, for ordinary copper is made brittle, both by hydrogen[10] and by manufactured[11] gas.

A more recent development has been the use of Electrolene[12] to provide an artificial atmosphere for electric furnaces.

[8] W. Trinks. Fuels and Furnaces for Heat Treating. *Transactions American Society for Steel Treating*, Vol. 8, July 1925, page 58.

[9] R. G. Guthrie. The Effect of Furnace Atmospheres on Steel. *Transactions American Society for Steel Treating*, Vol. 15, Jan. 1929, page 96.

[10] N. B. Pilling. Action of Reducing Gases on Solid Copper. *Transactions American Institute of Mining & Metallurgical Engineers*, Vol. 60 (1919), page 322.

[11] W. H. Bassett & J. C. Bradley. Action of Reducing Gases on Heated Copper. *Transactions American Institute of Mining & Metallurgical Engineers*, Vol. 73 (1926), page 755.

[12] F. P. Wilson, Jr. The Application of Oxygen and Hydrogen to Industrial Operations—Electrolene. *General Electric Review*, April 1930, page 222.

Electrolene is the product of complete or partial thermal decomposition of manufactured gas, natural gas or butane with or without steam in an electrically heated producer to produce mixtures containing carbon monoxide, hydrogen, and carbon dioxide as the main constituents.

The source of heat has a marked effect on the control of furnace atmosphere. In heating steel for heat treatment, the furnace atmosphere desired is fairly well determined, and in operation seems obtainable with all of the sources of heat to the degree necessary from a practical viewpoint. The furnace atmosphere required for heating the various non-ferrous metals and alloys also is evident, but the method of securing it does not seem to be positively determined yet, whether, by control of products of combustion or by creation of an artificial atmosphere.

The source of heat for heat treatment influences quality production at a low over-all cost, through its effect on—heat cost, cleanliness and working conditions, maintenance cost and furnace atmosphere. It is one of the major factors in heating for heat treatment, but is not the controlling factor. A source of heat best suited for one operation or form of furnace may not fit another. Form of furnace and source of heat should proceed hand in hand toward quality production at low over-all cost. The viewpoint of both the furnace manufacturer and the producer of the source of heat should be consulted, but the final decision must be made by the user. It is not, however, a problem of the heat treating department only, but one requiring the accumulative opinion of the whole manufacturing organization. It is a broad economic problem involving the economics of the local situation, as disclosed by the over-all cost of a finished product of suitable quality with the correct source of heat applied to the form of furnace best adapted to the heat treating operation and to local plant conditions.

# Sand Control in the Steel Foundry

By H. D. Phillips*

Sand and sand preparation are very potent variables in the production of castings. They are extremely important factors in the foundry, being second only to the metal in affecting the quality and final appearance of the casting. There are, as has long been known, many variables in the manufacture of a casting, and any attempt to control at least the most important ones is a step toward the goal, at which the foundry, like any other modern industry, is aiming—close scientific control in all processes or departments.

In attempting to deal with the subject of sand and sand control, it is necessary to make certain reservations because sands are so diverse in character that their preparation and control are necessarily relative to their character and to the particular purpose in which they are to be applied in the production of castings. It is necessary, therefore, to limit this discussion to a consideration of the control exercised in the preparation of sand used for green sand steel molding.

The best basis for green sand in a steel foundry is a clean, washed and dried, silica sand of uniform grain size and spherical shape. A true spheroidal sand is hard to obtain and as a rule the closest approach is with a sand composed of particles, which were angular or sub-angular and have, by abrasion, become slightly rounded.

The main requirements of the sand to be used, granting that it has been properly milled or mixed, are as follows:—

1. To be sufficiently high in silica content and to have the minimum of alkalies in order to insure the necessary refractory qualities.
2. To be permeable enough to allow the escape of gases generated within the sand and mold.
3. To clean easily and well, leaving a good surface on the casting.
4. To be capable of accommodating itself to the linear contraction of the metal during cooling.
5. To be strong enough to withstand handling and the scouring action of the metal, (i. e., have sufficient green and dry strength).

There are three main elements to be controlled in this sand, as in any other molding sand, and they are moisture, grain size and bond, and to produce a uniform, high quality casting, they must be closely and consistently controlled.

Of these three factors to be controlled, moisture will be considered first. In a clean silica sand there is practically no water chemically combined as in the case of a naturally bonded sand, and, therefore, the only moisture to consider is that mechanically held in the sand introduced during the mixing or tempering, giving the sand its temper. An excess of mechanically held water results in a wet sand, but mechanically held water is, however, a necessary evil in a molding sand. Close control of moisture is, therefore, necessary in order to prevent excessively wet sand with its resultant harmful effect upon the casting. A dry sand, or one too low in mechanically held moisture, will not ram properly as the bond is not sufficiently mobile, and so there is, therefore, a minimum as well as maximum moisture content permissible in the sand. The moisture content of green sand is a dominant factor, but there must also be a definite relationship between the moisture content and the content of the bonding materials. Moisture content as a rule is usually expressed as a proportion in weight, whereas it is customary to take volume as a basis for a sand mixture and there is bound to be a complication in quoting the proportionality of water to binder or sand, unless the actual weight of a specified volume of binder is determined. With the washed silica sand as a base and bonded with a mixture of approximately equal parts, by volume, of Bentonite and a cereal binder, it appears essential that the bond, in order to function properly, be associated with from five to six times its own weight of water. It is also essential to limit the total amount of binder as it appears that when present in excess of its equilibric amount of moisture, it tends to produce cutting and spalling of the mold face.

Moisture in molding sand may be controlled by the use of a water meter, an electric indicator, a Grubb moisture tester, a moisture indicator or by oven test. Each type of testing equipment has its particular adaptations. The water meter controls the moisture by measuring the amount of water added to a given amount of sand. A moisture indicator gives an immediate moisture test, the Grubb tester gives a quick accurate test, while an electric indicator gives the relative moisture content of the sand. The oven test is standard for moisture testing where time is not an important factor, and where large expenditures for special equipment must necessarily be avoided.

The second factor in connection with sand control is the character and size of grain. The sand grains comprise the refractory structure of the sand and control tests are for the purpose of determining permeability and fineness. The permeability test is well known and is the best method available for controlling the venting ability of the sand, as it is a rapid and direct measure of the sand's permeableness. Fineness tests, or screen analyses furnish many interesting facts con-

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cerning a sand. The coarse grains, namely those coarser than 100 mesh, act as the foundation of the grain structure, and the fines consisting of the material finer than 100 mesh act as the carrier of the bonding material. A definite proportion of fines is desirable but an excess is harmful and must be avoided. Summarizing, sand grains give the pores or permeability, and the structure or backbone to the sand, as well as the finish to the casting.

Third of the factors to be considered in sand control is the bond. It gives the sand its green or dry strength but reduces its refractoriness. It is like water a necessary evil and should never be used in excess. Green strength is that which is apparent when the molder feels the sand with his hand. It is only useful during molding, transportation and closing of the mold. It may be tested as to compression, shear, tensile or cohesiveness factors. The sensitiveness of all these tests is practically the same, all of them giving satisfactory control. The rapidity with which the first three tests are made is about the same for each, the cohesiveness test, however, being considerably slower. The compression test is the A. F. A. standard test, all others being tentative control tests. Dry strength is the strength saving the castings after the molten metal strikes the mold. As soon as the molten metal comes in contact with the surface of the mold, the moisture is instantly evaporated and the green strength is no longer of importance, dry strength taking its place. There is no definite relationship between green and dry strength but fortunately the majority of molding sands have sufficient dry strength to give fair results. It is an element requiring close control, if excessive, greater shake out effort with increased flask breakage, and cracked castings will result. If insufficient, poor dirty castings with numerous dirt inclusions and scabs may be expected. By the addition of small percentages of Bentonite to the sand, dry strength can easily be controlled. The dry strength test is made by baking the A. F. A. standard sand specimen for two hours at 212° F. When cool, the specimen is broken in a sand strength machine.

In steel foundry practice, there are generally two different classes of sand used in making a mold, namely, facing sand and backing or heap sand. Ideal operating conditions demand that these two classes of sand have at least equal permeability, or better, that the backing sand be of higher permeability than the facing. It is also imperative that the moisture content does not exceed 3.5%, by weight, unless the sand is allowed to stand over a protracted period of time before use, in which case 4% is satisfactory. These two elements, low permeability and high moisture content, are the main culprits to be dealt with in the molding sand used for steel castings.

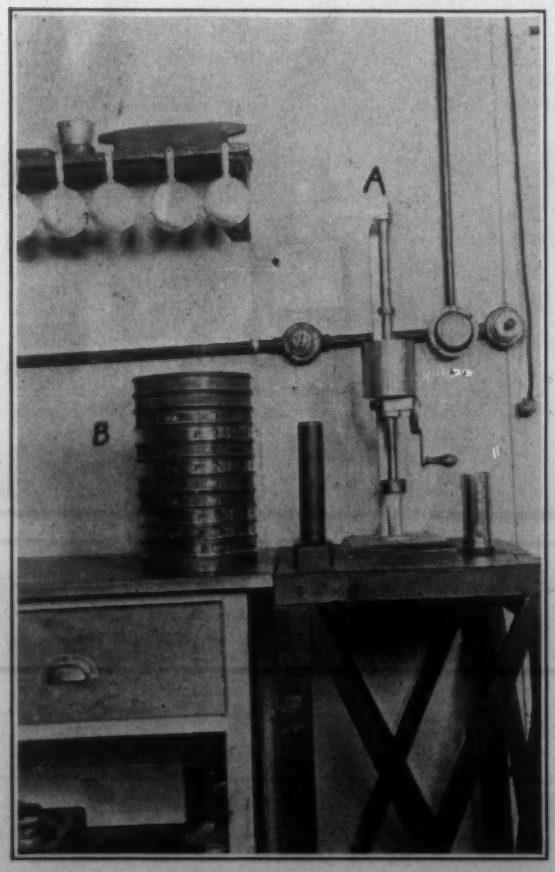


Fig. 1—(A) Standard Sand Rammer for Permeability, Shear and Compression Tests, Used for Both Green and Dry Molding Sand Testing. (B) Sieves for Determining Screen Analysis of Sand

If the sand is too dry, the bond is not mobile enough and trouble may be expected of the following nature; cutting at corners and gates; bad pattern draws; low dry strength; cope drop-outs. If too wet there is great danger of bad pattern draws, blowholes, sagging of molds and misruns due to the added weight and plasticity of the sand with the increased generation of steam. There is more than enough water to make the bond 100% efficient and the sand is, therefore, dangerously wet.

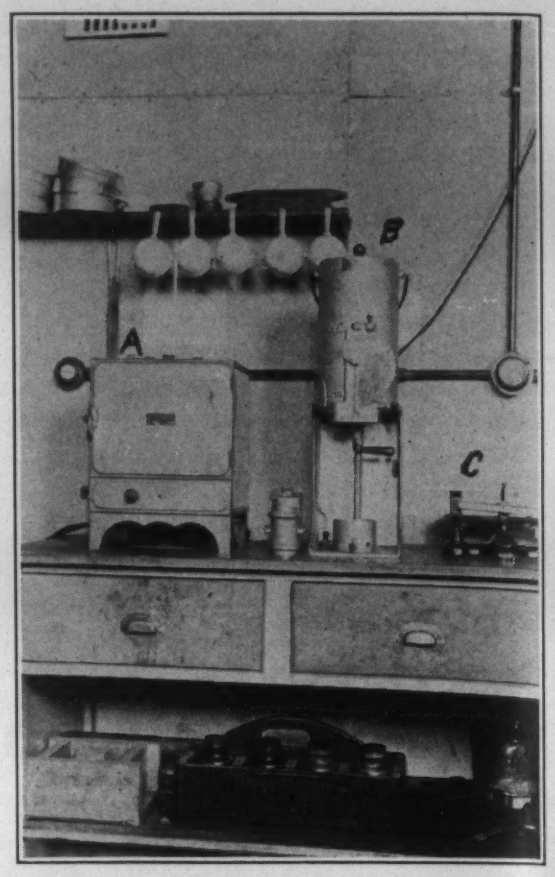


Fig. 2—(A) Electric Oven Used for Drying Sand, Both for Moisture and Dry Strength Testing. (B) Direct Reading Permeability Machine. It Is also Possible to Use This Machine for the A. F. A. Stop Watch Research Method. Tubes to the Left Are Used in Determining Permeability of Dry Specimens. (C) Small Laboratory Scale Used for Weighing Sand to Be Tested.

Granting that the moisture content is correct but the sand is too coarse or sharp, trouble may be expected from roughened castings with considerable metal penetration along with cutting at sharp corners and drop-outs. If the sand is of too fine or of too low permeability trouble may be expected from blowholes, scabs and kicks. It will be attempted later to illustrate the manner in which trouble from these sources may occur.

Before any attempt was made to scientifically control sand in the foundry, each molder conditioned his own heap and the quality of the facing sand rested with the operator of the sand mill. The molder's methods of conditioning and his judgment depended upon his experience alone, and if by any chance a new sand came to his hands it would in all probability require considerable time and the loss of some castings until he found out just how to treat this new sand. He tested the moisture content by the feel of the sand to his hand, it was either too wet, too dry or just right. The green strength was determined by breaking a handful of sand in his hand and the permeability by squeezing a handful of sand,

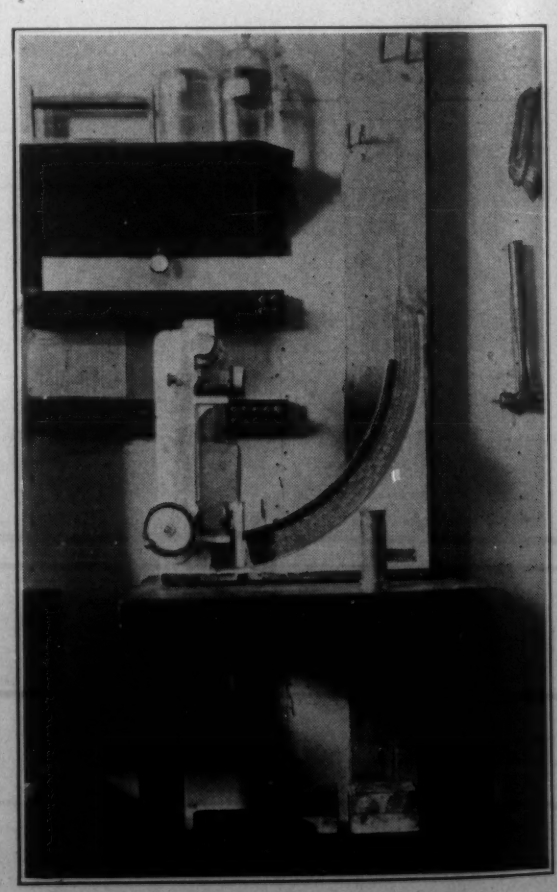

Fig. 3—Sand Strength Machine Used for Testing Green and Dry Shear and Compression Strengths of Molding and Core Sands. It Is a Direct Reading Machine Giving the Sand Strength in Lbs./in².

putting it to his lips and blowing through it. He knew by his experience that if the sand were too wet or too dry that he could expect low green strength and permeability. In breaking the handful of sand he noted that it was either too fine or too coarse and from the feel of the sand formed an idea of its strength and the liability of the danger of cutting, metal penetration, drop-outs, scabs and blow holes. He knew by blowing through the sand what to expect of the sand's venting ability. He made all these practical tests perhaps without realizing that he was testing the sand. The "human element" with its attendant "guess work" was always present. The modern production methods in the steel foundry do not permit of the individual conditioning of sand with the dangers involved, and modern equipment calls for more exacting control of the sand.

It will be attempted to illustrate the manner in which scientific sand control has aided in fighting that bane of all steel foundrymen, pinholes or blow holes. A blow hole in a steel casting, not caused by improperly refined metal, is formed by the dissociation products of water. The great heat of the metal upon entering the mold causes this dissociation of moisture ($H_2O$), the hydrogen apparently being partially absorbed by the metal, the oxygen oxidizing the interior of the blow hole as the casting cools down. The chief culprit in the formation of blow holes is moisture combined sometimes with low permeability. When metal enters a green sand mold the heat first of all causes an expansion of the air, which fills the spaces between the sand grains. This is equal to trying to increase the volume of air within the sand, this sand must then necessarily be permeable enough to allow the free venting of this expanded air, preventing excess pressure of air within the sand which would bubble back into the steel.

The second effect of the heat of the metal is to convert the moisture at the face of the mold into steam. This steam moves away from the face of the mold along the pores of the sand the same as the expanded gases would, but it, however, soon comes into contact with sand cold enough to condense it and again change it to water. All these changes take place very quickly and it is but a short time after the metal enters the mold that a film of condensate is formed in the sand within a short distance of the face of the mold. The heat of the metal continues to penetrate the sand and converts the inner face of the condensate film into steam again. The remainder of the condensed water tends to fill the inter-particle spaces of the sand thus locally lowering its permeability. This condensate film, therefore, is somewhat of a barrier to the escape of the steam between it and the face of the mold, and unless the permeability of the sand is great enough, some of the steam will burst through the thin solidified envelope of the casting, causing blow holes. These blow holes are very likely to appear at a corner or re-entrant angle of the mold, due to the fact that it is generally exposed to a greater heat attack.

The elimination of re-entrant angles and sharp corners within a mold will aid greatly in doing away with this danger, but the real source of the trouble lies with the sand and, therefore, must be primarily attacked from that angle.

As has been stated before, sand used throughout the mold should be of spherical shape. Sand of angular shape will pack so closely that the spaces between the grains are discontinuous and become blind passage ways through which the gases cannot escape. The grain size is very important because the sand should be fairly regular so that there may be uniformity of spaces throughout. A mixture of fine and coarse particles will result in a sand of low permeability as the fine sand closes or chokes up what would have been the pores or spaces through the coarse sand. The bonding material should be of such nature as to result in the uniform covering of each sand grain with a thin coat of bond, and not be present in excess, nor diluted to too great an extent by fine material such as disintegrated sand grains, perished bond, or silica flour, as the bond film on each grain of sand will then be so thick that in ramming the sand, the normally existent pores will be choked by the bond. Typical analyses of ideal steel molding sands are given in Table 1. The sand used as heap sand is a reclaimed sand, having the larger proportions of fines removed, while the facing sand is washed and dried silica sand.

**Table 1—Screen Analysis of Steel Molding Sands (Green Sand)**

| Mesh | Facing Sand % Retained | Facing Sand Cumulative | Heap Sand % Retained | Heap Sand Cumulative |
|---|---|---|---|---|
| 6 | .. | ... | .. | ... |
| 10 | .. | ... | .. | ... |
| 20 | .. | ... | .. | ... |
| 28 | 0.3 | 0.3 | .. | ... |
| 35 | 0.7 | 1.0 | 12.1 | 12.1 |
| 48 | 7.5 | 8.5 | 32.6 | 44.7 |
| 65 | 23.5 | 32.0 | 29.3 | 74.0 |
| 80 | 41.6 | 73.6 | 20.5 | 94.5 |
| 100 | 16.2 | 89.8 | 2.7 | 97.2 |
| 150 | 4.1 | 93.9 | 1.3 | 98.5 |
| 200 | 3.9 | 97.8 | 0.6 | 99.1 |
| 270 | 1.8 | 99.6 | 0.3 | 99.4 |
| Pan | 0.4 | 100.0 | .. | 99.4 |
| Moisture | 0.0 | 100.0 | 0.6 | 100.0 |

If the moisture content is excessive there is almost bound to be an extravagant generation of steam within the sand at the face of the mold and it is then practically certain that the casting will be contaminated with blow holes at re-entrant angles or corners of the mold. Over-ramming of the sand in the mold is very prone to cause trouble from blow holes because it tends to close the inter-particle spaces between the grain. Molding methods have considerable influence on the ramming. The plain jolt machine is by far the best way of molding, giving a uniformly rammed sand and tending toward closer packing of the sand near the pattern, thus maintaining ideal mold conditions.

In order to keep the correct permeability and grain size of the sand, a method of reclamation is necessary to reduce the deleterious fines continually being introduced into the sand in mixing, in pouring of the mold and in handling. It is not intended to even generally discuss this here as even a very general consideration would require the writing of a lengthy paper. It may be stated though, that along with the removal of fines from the sand it is at times, though seldom, necessary to make additions of a coarse sand to the heap, to maintain the proper permeability.

By numerous experiments it has been found that the following conditions of sand are practically ideal, in view of our present-day knowledge, and aid greatly in the production of good, sound steel castings with excellent surface. Sand control can be established to maintain these conditions constantly, and, thereby, produce castings of uniform quality. It can easily be realized that it is a much larger undertaking to control sand in a small jobbing foundry than in a large specialty foundry, but by proper methods it can be simply and efficiently accomplished. The figures given in Table 2 can be easily maintained within the given range.

**Table 2—Data on Test Values of Steel Molding Sands**

| Sand | % Moisture | Shear Strength Lbs./in.² Green | Shear Strength Lbs./in.² Dry | Compression Strength Lbs./in.² Green | Compression Strength Lbs./in.² Dry | Permeability |
|---|---|---|---|---|---|---|
| Facing | 3.0 to 4.0 | 2.5 to 3.0 | 35.0 to 40.0 | 8.0 to 9.0 | 85.0 to 95.0 | 140 to 180 |
| Backing | 2.5 to 3.5 | 1.5 to 2.0 | 25.0 to 30.0 | 5.0 to 6.0 | 60.0 to 70.0 | 180 to 250 |

Tests should be taken every half hour on the facing sand and every hour or oftener on the backing sand, from different floors. In a large foundry, having continuous conditioning equipment, tests may be taken every quarter-hour or every hour, depending at all times upon the number of tests necessary to maintain the desired conditions.

Along with these laboratory tests there is necessary a certain amount of cooperation from the molders and molding foremen. The proportion of facing sand to metal section and backing sand in a mold plays a big part in the quality of the casting as well as molding costs.

Considering the proportion of facing to backing sand, it

has been found advisable to use approximately one half inch of the fine, low permeability sand around the pattern in making the mold. There are permissible and at times necessary variations in this practice. In making a mold for a small casting or one of thin metal section, 1/4 inch of fine sand is best, whereas for a large casting, 3/4 inch is permissible. This variation is due to increased metal in the mold with its correspondingly increased heat penetration of the sand.

By remembering the theory previously given pertaining to the cause of blow holes in steel castings, when the mold is at fault, which in the present-day light and knowledge of steel making is usually the case, it can readily be understood why there should be a proportional amount of facing sand to metal section, or casting weight, disregarding altogether the cost or economic question of using undue amounts of milled and bonded sand.

Taking as an example a 200-pound steel casting of approximately four inch metal section with 1/4–3/8 inch of facing sand adjacent to the metal, which has been poured at a fairly standard pouring temperature of 2850–2950° F. By remembering the first action that takes place within the sand when the metal first fills the mold, namely that of an expansion of the air which fills the spaces between the sand grains, it can be seen why a heavier section of, say, one inch of facing sand would cause trouble. The heat of the metal would expand this air to a great extent and the low permeability facing would not allow the passage of this air away from the face of the mold, causing, thereby, a belt of extreme pressure adjacent to the mold face. This air then accepting the path of least resistance would bubble back into the steel, the pressure of the air being great enough to puncture the initial low tensile strength envelope of the casting. With only 3/8 inch of low permeability facing backed by the higher permeability heap sand, this expanded air, again accepting the path of least resistance, would flow away from the face of the mold and thus eliminate any danger from this source.

The change to steam and consequent condensation of the moisture at the mold face caused by the penetration of the heat of the metal into the sand is really the most important reason for so proportioning the ratio of facing sand to metal section or weight. As has been mentioned before, moisture is the most formidable culprit in the formation of blow holes in steel castings. When the moisture is changed to steam by the heat of the metal, it travels away from the face of the mold but soon comes into contact with sand cool enough to condense it. This heat given off by the metal continues to penetrate the sand, converting the inner-face of this condensate film into steam again, and if the sand is too impermeable as would be the case if an inch or more of low permeability sand were used as a facing, the steam would blow back and puncture the thin solidified envelope of the casting. The first condensate film formed close to the mold face so lowers the permeability of the sand that the steam cannot escape through it if too much of the fine sand is used, but if only 1/4 inch of facing sand were used backed by a more permeable heap sand, the steam could escape deeper into the mold away from the face, thus doing away with the danger of pinholes. And again, if there were any danger of a blow back with this sand, it would so be delayed that the envelope of the casting would be strong enough to resist any penetration.

A general summary of the manner in which sand should be controlled in a steel foundry is as follows:

1. The moisture should be so controlled as to allow proper molding and to avoid spraying of the sand after it is in the flasks (which would naturally result in localized wet and impermeable spots).
2. The permeability of the heap or backing sand should always be greater than that of the facing sand.
3. The compressive strength in lbs./in.$^2$ should be great enough to allow quick and proper molding, without which it is possible that the sand may weaken and collapse.
4. The grain size of the sand should be adjusted to give the desired surface on the casting.
5. The silt, fines and active bond should be held under 10.0%.

It is believed that by observing these conclusions the full benefit of sand control may be achieved in the steel foundry. As has been stated before, a method of removing the deleterious fines or matter closing up the pores of the sand is necessary in order to continuously operate with a low permeable face and a highly permeable backing sand. It is necessary to strike a cycle by which these fines introduced by the use of fine sand as a facing, combined with the perished bond, being continuously added to the sand are as well continuously removed. If some means were not on hand of so cleansing the sand, it would soon, due to the rapid accumulation of these detrimental elements, become dangerously low in permeability.

Lastly, coming to the question of grain size and its influence upon the finish of the casting—it can easily be understood that the finer and purer the grade of silica sand used, the finer and cleaner surface will be obtained on the casting. In small electric foundries it is by far the best practice to use a fine facing sand while in open-hearth shops where the temperature of the metal poured is as a rule much lower, it is possible to use a slightly coarser grade of sand as a facing, and still obtain a good finish on the casting.

In the reclamation of sand, that passing through the coarser meshes up to approximately 65 mesh is retained to be used as heap sand and the finer material is added in part or wholly to the facing sand thus lowering considerably the consumption of new sand and binder, a factor of great interest and importance to the management. No elaborate means of reclamation are necessary and are to be warned against rather than approved. However, by simple efficient sand reclaiming devices, economies in sand and other materials may be obtained along with considerably higher quality castings.

Sand control is no longer a trial or experiment, as it was formerly viewed by foundrymen, but has established itself as a very important factor in the manufacture of sound, clean steel castings. By the use of scientific sand control one of the most dangerous and potent variables in the production of a casting has been practically eliminated. Without it, the elements moisture, permeability, grain size, and bond, so important to sand could not be controlled and the sand would still be prepared and handled by "rule of thumb" or traditional methods.

## Haynes Stellite Company Opens New Foundry

Haynes Stellite Company, Kokomo, Ind., a unit of Union Carbide and Carbon Corporation, has announced the completion of a new foundry at the Kokomo Works, which has been built expressly for the manufacture of the Hastelloys, a group of new acid resistant alloys. The most up-to-date and efficient foundry equipment procurable has been installed to insure careful control of quality and uniformity of product. The Hastelloys form a group of corrosion-resistant alloys with unique properties. They are of particular interest to those who have been faced with the hitherto difficult problem of providing suitable equipment for resisting the action of hydrochloric acid and moist chlorine. Hastelloy "A" is the only alloy, available commercially, which resists the action of both hot and cold hydrochloric acid, while Hastelloy "C" resists the action of wet chlorine.

The St. John X-Ray Service Corporation has installed what is said to be the first X-Ray plant of its kind at the Barberton, Ohio works of The Babcock & Wilcox Company.

The photographic apparatus will be used primarily for routine inspection of welded seams in pressure vessels, heat exchangers and similar equipment.

Dr. Ancel St. John, President and Technical Director says that the Babcock & Wilcox X-Ray plant is in all probability the most powerful of its kind.

# Origin and Effect of Inclusions in Steel†

## A Review

By B. M. Larsen*

(Continued from September)

### VII. Other Deoxidizing Elements

The foregoing discussions show how limited are the available data on the common deoxidizers. For the less common deoxidizing elements almost no data are to be found except empirical results of practical experiments and the vague conclusions drawn from them.

Titanium is a metal closely related to silicon in properties. As a deoxidizer, it presumably reacts with FeO,

$$2FeO + Ti \rightleftarrows TiO_2 + 2Fe \qquad (15)$$

to form inclusions of $FeO–TiO_2$ mixtures. No data are available on this oxide system. Titanium is available commercially only in the form of alloys in which it is associated with carbon and silicon, and sometimes with aluminum. It is supposed to have a deoxidizing power somewhere between that of silicon and aluminum, and is usually used as a finishing deoxidizer to replace aluminum, being supposed to give larger and less harmful inclusions than those from aluminum, and to have a tendency to combine with nitrogen to form tiny nitride inclusions suspended in the metal.

Zirconium apparently has a deoxidizing power approximating that of aluminum. There are indications also that it combines with sulphur and nitrogen to form insoluble sulphide and nitride inclusions. It is available commercially only in mixtures with silicon and iron. Both titanium and zirconium are apparently difficult to prepare either in the pure state or in simple binary alloys with iron.

Chromium and vanadium are comparatively weak deoxidizers comparable perhaps with manganese as regards their affinity for oxygen in iron solutions. None of the oxide systems here involved, such as $ZrO_2–FeO$, $FeO–Cr_2O_3$, $ZrO_2–SiO_2–FeO$, etc., have been studied.

Hydrogen might be used as a deoxidizer, comparable in effect to carbon, the reaction being

$$FeO + H_2 \rightarrow H_2O + Fe \qquad (16)$$

No stable hydrides seem to be available for easily making hydrogen additions to liquid iron, and there are obvious difficulties in the way of bubbling the gas through a bath of metal. Most fuel gases give a large volume of water upon combustion, and this may play some part in the oxidation of the bath during an open-hearth heat; at least, the gases given off during the freezing of most ingots contain large percentages of hydrogen, presumably formed by the above reaction, proceeding in the reverse direction, from right to left. A converter arrangement in which hydrogen could be bubbled through the finished metal, might give some very interesting results. Carbon, sulphur and oxygen might all be eliminated to a considerable extent without leaving any solid non-metallic particles suspended in the finished metal; the metal would, of course, be saturated with hydrogen, most of which should be given off during freezing. Calculations from equilibrium data (given in detail below) such as those given by Eastman[1] indicate that a mixture of approximately 22% $H_2O$ and 78% $H_2$ should be in equilibrium with liquid iron containing 0.01% oxygen at around 1600° C. As mentioned above, similar calculations indicate that a mixture of about 96% CO and 4% $CO_2$ would be required to effect the same degree of deoxidation. This is a rough indication that hydrogen of ordinary purity should be a rather efficient deoxidizer; and at least a more efficient one than CO at steel-making temperatures.

The use as deoxidizers of calcium, magnesium, sodium and other metals with boiling points below the melting point of iron have been confined to a few scattered experiments, none of which have been carried far enough to permit definite conclusions to be drawn. If the vapors of such metals could be made to react effectively with the liquid metal, some very interesting results should be obtained.

### *Calculations of Equilibria in Deoxidation Reactions*

Because of the many difficulties of making direct experiments at steel-making temperatures, several attempts have been made to obtain approximate figures representing the "deoxidizing power," etc., of various substances. We have referred to some of these calculations by LeChatelier and McCance in the section on deoxidation with manganese. In order to bring out more clearly the necessarily approximate nature of such calculations, it may be worth reviewing some of the methods used very briefly. The Clapeyron equation in its differential form:

$$\frac{dP}{P} = \frac{\Delta H}{RT^2} \qquad (17)$$

is essentially accurate for representing the relation between the very small dissociation pressures (P) of substances like $H_2O$ and FeO, the heat of formation H, of these compounds and the absolute temperature T. To be of any use in calculations it is necessary to integrate the equation to form an equation like the following

$$ln P = -\frac{\Delta H}{RT} + \int \frac{\Delta C_p dT}{RT} + C \qquad (18)$$

LeChatelier's approximation was to assume the heat of formation to be independent of temperature (thus eliminating the term $\int \frac{\Delta C_p dT}{RT}$) and then to take an arbitrary value for the constant C which he had found to fit some other similar reactions. McCance's method was to use the equation (18) in a conventional form developed by Nernst,

$$\log P = -\frac{\Delta H_0}{4.575T} + 1.75 \log T - \frac{\epsilon T}{4.575} + C \qquad (19)$$

usually dropping out the fourth and sometimes the third term in the equation. He obtained more nearly correct values for the constant C by combining reactions in which the equilibria were measured, such as the deoxidation of FeO with hydrogen and the dissociation of water vapor. Applied to temperatures around 600–1150° C., McCance's method gives fairly accurate figures (within perhaps 20 or 25%) for the dissociation pressure of FeO; extrapolated to temperatures around 1500–1600° C., the more or less arbitrary nature of the Nernst equation introduces an unknown error. The fact that the heats of formation are so large compared to the entropy differences between the oxides and their dissociation products is what enables such calculations as those of LeChatelier and McCance to be fairly good approximations.

According to the method applied by Lewis and Randall[32]

† In three parts, Part II; Part I was published in September, Part III will be published in November.

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[32] Lewis & Randall, "Thermodynamics and the Free Energy of Chemical Substances," McGraw-Hill Book Co., 1923.

a form of equation (18) can be used for calculating the change of dissociation pressure with temperature, using known data for specific heats, heats of reaction and one or more measurements of equilibrium. Since such an equation is theoretically as accurate as the specific heat data, over the temperature range covered by this data, it is possible to repeat some of McCance's calculations with at least a slight improvement in accuracy. A few examples may be given here to show some of the limitations of available data.

Eastman and Evans[1] made equilibrium measurements over the range 675-1025° C. in the reaction

$$Fe + H_2O \rightleftarrows FeO + H_2 : K_{(20)} = \frac{(H_2)}{(H_2O)} \qquad (20)$$

The results may be expressed by the equation

$$\log K_{(20)} = \frac{840}{T} - 0.632 \qquad (21)$$

there being no specific heat data available for FeO.

Perhaps the best data for the reaction

$$H_2 + {}^1/_2O_2 \rightleftarrows H_2O \text{ (gas)} : K_{(22)} = \frac{(H_2O)}{(H_2)(O_2)^{1/2}} \qquad (22)$$

are those of Eastman.[2]

By using the relation

$$\Delta F^\circ_T = -RT\ln K, \quad \text{or } \log K = -\frac{\Delta F^\circ}{4.575T}$$

Eastman's free energy equation for reaction (22) may be expressed by the equation

$$\log K_{(22)} = \frac{12510}{T} - 1.01 \log T - 4.73 \times 10^{-5}T + 3.85 \times 10^{-8}T^2 + 0.4895 \qquad (23)$$

The equation

$$2FeO = 2Fe + O_2 \qquad K_{(24)} = P_{(O_2)} \qquad (24)$$

may be obtained by adding (20) and (22), reversing and multiplying by 2, so that

$$K_{(24)} = \frac{2}{K_{(20)} \times K_{(22)}} = -2(\log K_{(20)} + \log K_{(22)}) \qquad (25)$$

which gives the equation

$$\log K_{(24)} = \log P_{(O_2)} = -\frac{26680}{T} + 2.022 \log T + 0.946 \times 10^{-4}T - 0.769 \times 10^{-7}T^2 + 0.2863 \qquad (26)$$

This equation should give values of the dissociation pressure of FeO to within perhaps 10–20% of the true values when applied in the temperature range between 600 and 1100° C.; extrapolated to higher temperatures the uncertainty may become much larger. At 1600° C., the equation gives a value of $3.67 \times 10^{-8}$ atmospheres for the dissociation pressure of superheated solid FeO at 1600° C. We may assume that liquid FeO saturated with iron at 1600° would not be much different, and then take this value of $3.67 \times 10^{-8}$ atmospheres as a rough approximation to the oxygen pressure of iron saturated with FeO (about 1.35%) under a slag phase of pure FeO saturated with iron, since the oxygen pressure of both phases must be the same at equilibrium.

From equations (22) and (23), taking $1/K_{(22)} = K'_{(22)}$, then $K'_{(22)} = 1.253 \times 10^{-4}$ at 1600° C. Now,

$$K'_{(22)} = \frac{(H_2) \times (O_2)^{1/2}}{(H_2O)}, \text{ or } \frac{(H_2)}{(H_2O)} = \frac{K'_{(22)}}{(O_2)^{1/2}}$$

If a mixture of $H_2$ and $H_2O$ is in equilibrium with liquid iron saturated with oxygen at 1600° C., then the oxygen pressure of both phases must be equal, and

$$\frac{(H_2)}{(H_2O)} = \frac{1.253 \times 10^{-4}}{(3.67 \times 10^{-8})^{1/2}} = 0.654$$

or the gas phase would contain something like 60.4% $H_2O$ and 39.6% $H_2$. If we assume that in a more dilute FeO solution such as in ordinary rimmed or killed steels, there is 0.01% $O_2$ or 0.045% FeO and that the oxygen pressure is directly proportional to the percentage saturation,

$$p(O_2) = \frac{0.045}{1.35} \times 3.67 \times 10^{-8} = 1.223 \times 10^{-9} \text{ atm. (1600° C.)}$$

and $\frac{H_2}{H_2O} = \frac{1.253 \times 10^{-4}}{(1.223 \times 10^{-9})^{1/2}} = 3.58$ or $H_2O = 21.8\%$ and $H_2 = 78.2\%$.

Eastman gives for the reaction

$$CO_2 = CO + {}^1/_2O_2 \qquad (27)$$

the equation,

$$\log K_{(27)} = -\frac{14730}{T} + 1.227 \log T - 4.796 \times 10^{-4}T + 3.736 \times 10^{-8}T^2 + 1.529 \qquad (28)$$

By exactly similar calculations to those given above, this indicates that a mixture of about 4% $CO_2$ and 96% CO should be capable of reducing the concentration of oxygen in liquid iron to 0.01% at 1600° C.

By the same method of combining equations, we obtain the following for the equation

$$FeO + C = CO + Fe : K_{(29)} = \frac{(CO)[Fe]}{[FeO][C]} \qquad (29)$$

and

$$\log K_{(29)} = -\frac{7490}{T} + 2.097 \log T - 4.537 \times 10^{-4}T + 0.43 \times 10^{-8}T^2 + 1.633 \qquad (30)$$

$$\log K_{(29)} \text{ (at 1600° C.)} = +3.663$$

Suppose we imagine a solution saturated with carbon and FeO at 1600° C. (1.35% FeO, 5.5% C), and assume that the activities of Fe, C and FeO are all nearly unity, then $\log K_{(22)} = \log P_{(CO)} = 3.66$, or the pressure of carbon monoxide over such a solution would be about 4600 atmospheres. Then at one atmosphere CO pressure

$$C_{(29)} = \%\,C \times \%\,FeO = \frac{1.35 \times 5.5}{4600} = 0.00162$$

Besides the extrapolation from lower temperature data, this involves the more doubtful assumptions that the $Fe_3C$ is practically all dissociated in the saturated solution and that the activities of Fe, C and FeO are not affected by the presence of each other in the iron solution. There is no assurance here that the value obtained for $C_{(29)}$ may not be in error by 1000% or more.

These examples should serve to illustrate the sources of uncertainty in this kind of calculation for steel-making reactions. The worst uncertainty involved is in the tacit assumption that the simple relations found useful as close approximations in systems at low temperatures will apply in the same form at these extremely high temperatures. This, however, is exactly what we most need to find out, and to accomplish this we shall need comparisons between direct values from more accurate observations in high temperature systems and indirect values using more accurate and complete specific heat and free energy data than are now available, for such substances as FeO, MnO, FeS, MnS, $Al_2O_3$, $SiO_2$, etc.

## VIII. Compound Deoxidizers

No good data are available on the effect of adding two or more deoxidizing metals in the same alloys. If, for example, an alloy of silicon, manganese and iron is added to a saturated solution of FeO in iron, since the FeO concentration is far above the equilibrium values for both the manganese and silicon present, both metals will begin to react with FeO to form inclusions containing FeO, MnO and $SiO_2$. The rate of reaction with silicon will probably be highest, but if the reaction products form as liquid drops, equilibrium between FeO and both deoxidizing elements should be quickly reached. For a given residual concentration of FeO in the metal, the residual Mn and Si contents will be somewhat different from, probably lower than, those in Fig. 17. Substitution of MnO for part of the FeO in the slag phase forms $MnO{\cdot}SiO_2$ and $2MnO{\cdot}SiO_2$ in place of $2FeO{\cdot}SiO_2$. The manganese silicates are probably less dissociated than fayalite at a given temperature so that the concentrations of free $SiO_2$ and FeO are both reduced; this favors more complete deoxidation and probably over-balances the opposite effect of the MnO introduced into the metal. It happens that the slag in the acid open-hearth furnace is usually composed almost entirely of manganese

and iron silicates. A thorough study of equilibria in deoxidation with silico-manganese alloys would thus serve to explain the greater part of the chemistry of the acid open-hearth process.

It is often cheaper to make mixed deoxidizing alloys on account of the greater range of ore compositions made available. It should also be beneficial to use a mixed deoxidizer that would produce inclusions of lower melting point, especially if, for example, a certain mixture of the common deoxidizers could be developed that would be as complete in action as aluminum, and at the same time form larger liquid inclusions which consequently would rise more quickly out of the metal bath.

Aluminum-silicon alloys have been given a little study. With pure aluminum, the inclusions seemed to be so small as to resemble colloid particles, with very low rising rates in the liquid iron, so that the particles were distributed nearly uniformly throughout small test ingots. With moderate amounts of silicon in the alloys used, the inclusions were still small but sufficiently larger than the alumina particles to rise comparatively rapidly in the liquid metal, and were found strongly segregated in the top portions of small ingots. Such differences in effects of single and double deoxidizers suggest a profitable field for study in the effects of various binary and ternary combinations of the cheaper deoxidizing elements.

If all deoxidizing metals had about the same rates of reaction with FeO in the iron solution, the use of compound deoxidizers would be fairly simple. Even the few data so far available, however, indicate that this is not the case. If, for example, an alloy of aluminum and manganese is added, the rate of reaction of the aluminum is likely to be so rapid that under many conditions the inclusions formed will be nearly all $Al_2O_3$ particles. In any given case, the course of the deoxidizing reactions and the inclusions formed depend not only on the composition of the deoxidizer used, but also on the relative reaction rates, and the initial concentration of FeO in the iron. Furthermore, there is no theoretical justification for predicting reaction rates from the heats of the reactions between FeO and the various deoxidizing elements.

For these reasons, it looks as though the use of compound deoxidizers will have to be largely based upon empirical data. Certainly, no available mixture of deoxidizing metals can be depended on as a "cure-all" for various troubles in deoxidation, and an alloy found effective under given conditions of furnace operation and steel composition is very likely to have quite different effects when these conditions are changed. In certain cases it may prove to be better to use two or more single deoxidizers, each one added after the previous addition has nearly completed its effect, because of the closer control and simpler calculations, as compared to the use of a complex alloy.

## IX. Deoxidation Methods

If we consider in a general way the possible methods of deoxidation, we are again reminded that equilibria in deoxidation processes involve two important factors:

(1) Equilibrium between deoxidizing metals and FeO in the homogeneous iron solution.

(2) Distribution equilibrium between metal and slag phases for oxides such as MnO and FeO which are appreciably soluble in both phases.

The simplest method of deoxidizing iron is to take advantage of the second factor and "extract" the FeO from the metal by placing over it a slag free from FeO and MnO. In the electric furnace, with its controllable atmosphere, this is often possible. For example, in the manufacture of low-carbon, low-manganese metal in an electric arc furnace, the carbon and phosphorus are first diminished to low values under a highly oxidizing basic slag. This is removed and a slag mixture of lime, fluorspar, silica and a small amount of ground electrode carbon is melted in the bath. This slag immediately begins to absorb FeO from the steel. The FeO reacts with the carbon in the slag to form metal again, and by an occasional sprinkling of finely ground carbon over the surface of the slag, the FeO content is kept low in the slag and the bath finally becomes almost completely freed of oxygen.

Such a method introduces no insoluble inclusions into the bath, but is comparatively slow, involving the diffusion of FeO through the bath and across the slag-metal interface. Also it is not usually possible to approach complete deoxidation by such a process in the open-hearth furnace, with its oxidizing atmosphere. The general principle holds, however, and always, the lower the FeO content of the slag near the end of the heat, the less FeO will be left in the bath to form inclusions by reaction with the alloy additions.

In basic open-hearth practice, it might be feasible to partly eliminate suspended inclusions or dissolved FeO by a sort of washing or extraction process. For example a pouring dish could be used to separate the oxidizing slag from the metal before the latter enters the ladle. The ladle itself would be preheated and would contain an amount of perhaps a $CaO$–$Al_2O_3$–$SiO_2$ or $CaO$–$Na_2O$–$SiO_2$ slag nearly free from FeO which would be in intimate contact with the iron during the filling of the ladle and would cover the metal in the interval before teeming into the molds. Or, a simpler method would be to dump a certain amount of solid or liquid fluxing slag into the ladle at the beginning of tapping; or the steel might be allowed to fall first into a tall, narrow dish with a bottom tapping outlet, partly filled with liquid slag low in iron oxides.

The ordinary method of deoxidation takes advantage of the first equilibrium mentioned above, by the addition of an excess of a deoxidizing metal or alloy to the metal phase, to react with dissolved FeO. The result is the precipitation of a cloud of insoluble inclusions in the iron with all the resultant troubles attending the elimination of these particles, their segregation in the finished steel, etc. This method of deoxidation is very quick in action, however, since it is not limited by a number of diffusion rates, but only by the extremely rapid rates of reaction in the homogeneous iron solution at steel-making temperatures.

## X. Iron Sulphide Inclusions: The Fe–FeS System

In the absence of oxygen, iron and sulphur form a very simple system, as shown by the diagram of Fig. 18. The lines given are those from the diagram of Loebe and Becker[33]

[33] Loebe, R., & Becker, E., Das System Eisen-Schwefeleisen. *Zeitschrift für anorganische Chemie*, Vol. 77 (1912), pages 301–319.

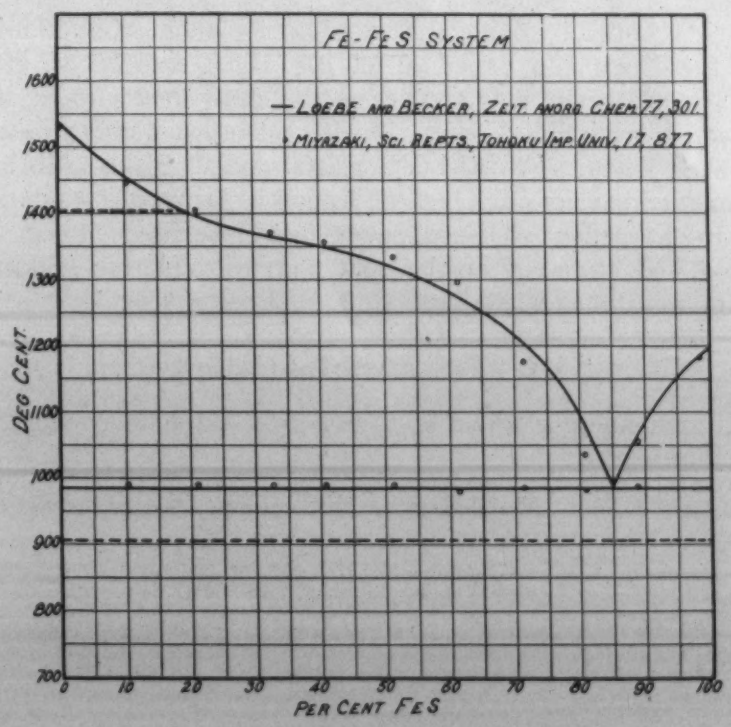



**Fig. 18—Equilibrium Diagram of System Fe–FeS**

and the points are those obtained by Miyazaki;[34] the substantial agreement indicates that in general outline the diagram may be regarded as fairly well established. FeS is completely miscible with iron in the liquid state, and forms with iron a simple eutectiferous series, with the eutectic of about 85% FeS and 15% Fe melting at 985° C. ± 5°. The melting point of FeS is given as 1195° C. ± 5° by these workers. Allen, Crenshaw and Johnston[35] give the melting point as 1170° C. ± 5°. Miyazaki concluded that FeS is completely insoluble in solid iron but his results might still allow a solubility of around 0.10% FeS or less. The critical points of iron in his work were not measurably affected by sulphur, which would indicate a lack of solid solubility. Andrew and Binnie[36] have recently determined critical points in melts of Armco iron containing around 0.25–0.50% S in which one portion of the metal was rapidly quenched from the molten state and another cooled slowly in the furnace. The observed changes in $Ar_3$ indicate a small solid solubility in iron at 900° which increases slightly as the melting point is approached. In one series containing 0.35% sulphur, for example, the original Armco iron gave $Ar_3$ at 887°, the furnace-cooled portion 882° and a quenched portion 872° C. On reheating the latter to above the eutectic melting point, $Ar_3$ rose to 877° C. These results still leave some doubt about the existence of solid solubility of S in iron and give no indication of its magnitude. It seems probable, however, that the solid solubility curves of FeS resemble those for FeO given tentatively in Fig. 9.

Iron sulphide inclusions form by the freezing at 985° C. of the last liquid portions left between the grains of iron, and are usually present not as globules but as thin envelopes following grain boundaries. These areas are a light yellow in color, and are easily attacked by etching reagents. Heyn and Bauer devised a means of identification by stretching a thin silk rag wetted with HCl and mercuric chloride over the surface of a polished section. Black mercuric sulphide is precipitated in the silk in areas in contact with FeS and a "sulphur print" obtained. Baumann's method of using photographic print paper wetted with dilute $H_2SO_4$ is easier but does not distinguish between sulphur and phosphorus-rich areas, as does the former method (silver phosphide dark, mercuric phosphide light yellow). A drop of thick, slightly acid gelatin solution containing cadmium or mercury salt may be applied to the surface under a low power microscope objective; iron sulphide areas cause a precipitate in the gelatin immediately above.

Van Royen and Ammermann[37] describe a modified method of obtaining sulphur prints, claiming greater clearness and less exaggeration of segregate areas than either the Heyn and Bauer or the Baumann process. Bromide paper, freed of silver bromide by fixing and washing, is soaked about 10 min. in the Heyn and Bauer sol. of 10g. $HgCl_2$ and 20 cc. HCl in 100 cc. water; it is pressed on the clean steel surface, the dark adhering film is wiped off with cotton wool under water, washed 1 hour and dried on a glazed plate. Black areas are sulphide inclusions and high-phosphorous segregates are shown in bright yellow. Glazed paper should be used; it can be dried and stored after the acid mercuric chloride soaking, being moistened with dilute (1:5) HCl before use.

## XI. FeS–MnS Inclusions

If manganese is added to an iron–iron sulphide system the reaction

$$Mn + FeS \rightleftarrows MnS + Fe \qquad (31)$$

occurs, and because of the greater stability of MnS compared to FeS the equilibrium concentrations of manganese are small compared to that of iron. The equilibria in the reaction have not been even approximately measured. With the relative amounts of manganese and sulphur usually present in commercial steels, more sulphur is probably present as MnS than as FeS; nothing more definite than this seems warranted by the available data.

The Mn–MnS system has not been studied. Herty and Gaines[38] found that a drop in sulphur occurred in pig-iron during transfer from blast furnace to open-hearth and showed that this drop was caused by the separation from solution of a sulphide consisting largely of MnS. The final temperatures at the mixer were all very close to 1315° C. and they found that over a considerable range in manganese, the manganese and sulphur contents could be given quite closely by the expression

$$(\%\ Mn)(\%\ S) = 0.07$$

This limited solubility of MnS in iron appears to increase with rise in temperature, but the saturation values for manganese and sulphur at temperatures in the steel-making range have not been determined. Andrew and Binnie,[36] however, prepared carbon-free melts containing as much as 1.4% Mn and 0.31% S. In each melt, part of the metal was poured into a chill mold while the remainder returned to the furnace to cool and freeze very slowly. Manganese and sulphur contents were found to be the same in the chilled and furnace cooled portions in all of these melts, which indicates that all of the sulphides must have been in solution in the liquid melts and have separated out during freezing. The photomicrographs of these melts give the same indications, the MnS–FeS inclusions being more or less rounded particles arranged in patterns around the grains of iron. The critical points obtained by the authors on these alloys gave no very consistent indications, but seemed to point to the conclusion that the very low solid solubility of sulphur was made even smaller by the presence of manganese.

The system MnS–FeS was studied by Röhl,[39] with the results given by the crosses in the diagram of Fig. 19. A eutec-

[34] Miyazaki, K., The Equilibrium Diagram of the Iron–Iron Sulfide System. *Science Reports Tohoku Imperial University*, Series 1, Vol. 17 (1928), pages 877–881.
[35] Allen, E. T., Crenshaw, J. L., & Johnston, John, The Mineral Sulphides of Iron. *American Journal of Science*, Vol. 33 (1912), pages 169–236.
[36] Andrew, J. H., & Binnie, D., The Solubility of Iron and Manganese Sulphides in Steel. 3rd Report of Committee on Heterogeneity in Steel Ingots. *Iron and Steel Institute*, May 1929.
[37] Van Royen, H. J., & Ammermann, E., Verfahren zum Nachweis von Schwefel in Stahlschliffen. *Stahl und Eisen*, Vol. 47 (1927), pages 631–632.
[38] Herty, C. H., Jr. & Gaines, J. M. Desulphurizing Action of Manganese in Iron. *Transactions American Institute of Mining & Metallurgical Engineers*, Vol. 75 (1927), pages 434–439.
[39] Röhl, G., The Constitution of the Sulphide Enclosures in Iron and Steel and the Desulphurization Process. *Iron & Steel Institute, Carnegie Scholarship Memoirs IV* (1912), pages 28–79.

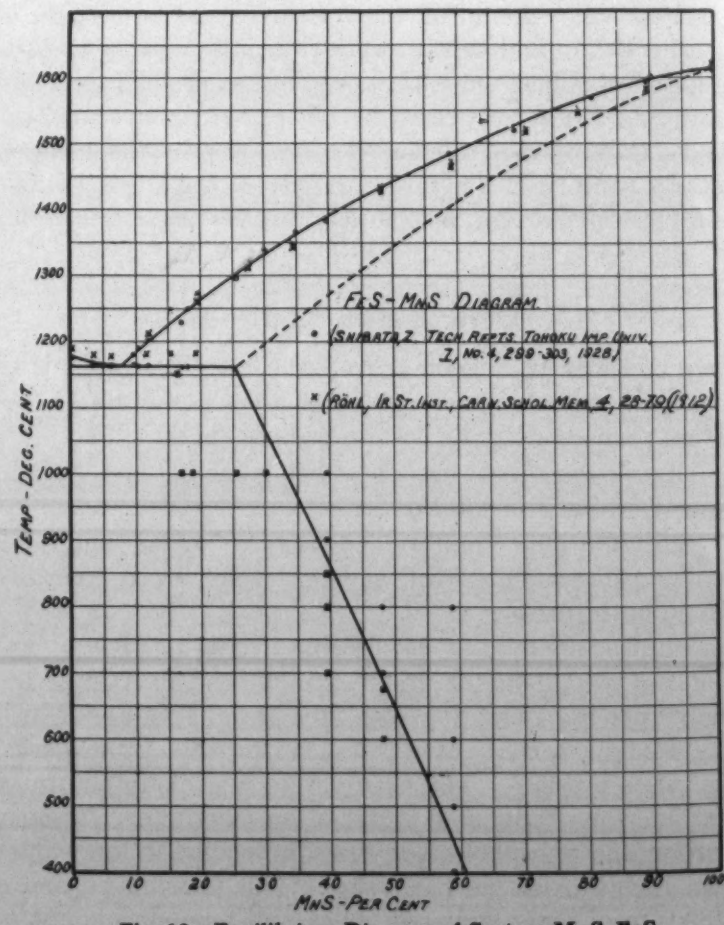



**Fig. 19—Equilibrium Diagram of System MnS–FeS**

tic was indicated at about 7.5% MnS; this eutectic arrest was found up to around 20% MnS, while duplex structure existed in the melts up to about 39% MnS. Röhl interpreted this as indicating the existence of a compound at this point (3FeS·2MnS, 39.2% MnS, 60.8% FeS) which seems rather doubtful. With more than 39% MnS, the melts were apparently homogeneous solid solutions. The lines in the diagram as drawn are according to the later work of Shibata.[40] On the basis of the data available, we should expect that the sulphide inclusions in all steels containing even small amounts of manganese are mixtures of FeS and MnS. With small amounts of manganese present, inclusions with duplex structures and rather low eutectic melting points would be present. With the condition common in commercial steels, of a rather large excess of manganese over the amount necessary to combine with all the sulphur, the inclusions should be homogeneous solid solutions of MnS and FeS with much higher melting points, increasing as the percentage of excess manganese increased.

Inclusions of nearly pure FeS are pale yellow, but the solid solutions of FeS and MnS are more nearly white, with a bluish tinge under certain kinds of illumination. One very noticeable difference is the tendency of the MnS-FeS particles to form rows of separate globules, more or less rounded, instead of the more or less continuous films formed by the FeS inclusions when very little or no manganese is present. Since it seems fairly certain that no sulphide inclusions in ordinary commercial steels are ever precipitated in the liquid metal, these rounded shapes may be attributed to three possible factors: (1) The higher melting temperature of the solid solution MnS–FeS particles. (2) A shifting of the eutectic point with increased manganese. In pure Fe-S alloys, the eutectic is at about 15% iron, which means that nearly all of the alloy has solidified before the sulphide separates from solution in the very narrow interstices left between the grains of iron; if manganese shifts the eutectic over toward the iron corner of the diagram, more metal would be present to freeze along with the sulphides. (3) A higher surface tension relative to iron with increasing MnS in the inclusions.

Röhl[39] gives the following method for distinguishing between FeS and MnS-FeS inclusions: The polished section is etched 3 or 4 min. with a solution of 1% picric or acetic acid in ethyl alcohol. (FeS tinted brown, MnS remains light blue.) The section is then heat tinted to a dark yellow in the ferrite by placing the specimen on an iron plate, face up, and heating gently with a Bunsen burner underneath the plate; it is then cooled rapidly in mercury. The FeS areas become dark blue, but with a large amount of MnS in them, they remain a dull gray to a bright white.

For the elucidation of the various relations of manganese and sulphur in iron, thorough work is needed along the following lines:

(1) Study of the MnS–Mn system.

(2) Further study of the MnS–FeS system.

(3) Study of the ternary system Mn–Fe–S, determinations of equilibrium of FeS and MnS in equation (12) and data on the free energies.

## XII. Rate of Rise of Inclusions in Molten Iron or Steel

Almost no experimental data are available regarding the rates of rise of oxide particles in liquid steel. Stokes' law may be expected to apply rather closely, since most inclusions in steel which has not been rolled or forged are found as small spheres and are present in rather low concentrations. Stokes' law for rise or fall of spheres in a liquid, applied to inclusions in iron at, say, 1600° C. would be as follows,

$$V = \frac{2ga^2(d_1 - d_2)}{9\eta} \qquad (32)$$

where $\eta$ = viscosity of molten iron (assumed to be 0.017 poise)
$d_1$ = density of inclusion particle, gram/cm.$^3$
$d_2$ = density of molten iron at 1600° C. (assumed as 7.0 gram/cm.$^3$)
$g$ = acceleration of gravity constant = 980.7 cm/sec.$^2$
$-V$ = velocity of rise in cm./sec.
$a$ = radius of inclusion particle in cm.

or,

$$-V = \frac{2 \times 980.7(7.0 - d_1)a^2}{9 \times 0.017} = 12819\ (7.0—d_1)a^2$$

*Example:* Assume $d_1 = 3.0$, and $a = 0.005$ cm. (diam. = 100 microns.)

$$-V = 12819 \times (7.0—3.0) \times 0.005^2 = 1.28 \text{ cm./sec.}$$

Since the particles are approximately or exactly spherical, any shape-factor correction should be small, except for the case of tiny inclusions which form groups of particles, partially fused or fritted together, as is often the case with inclusions of $Al_2O_3$, alone or with $SiO_2$.

The viscosity of liquid iron or low-carbon steel has not been determined, but Thielman and Wimmer[41] have measured the viscosity of several iron-carbon alloys, with results as shown in Fig. 20. The extrapolation indicated, to 1600° C., is, of

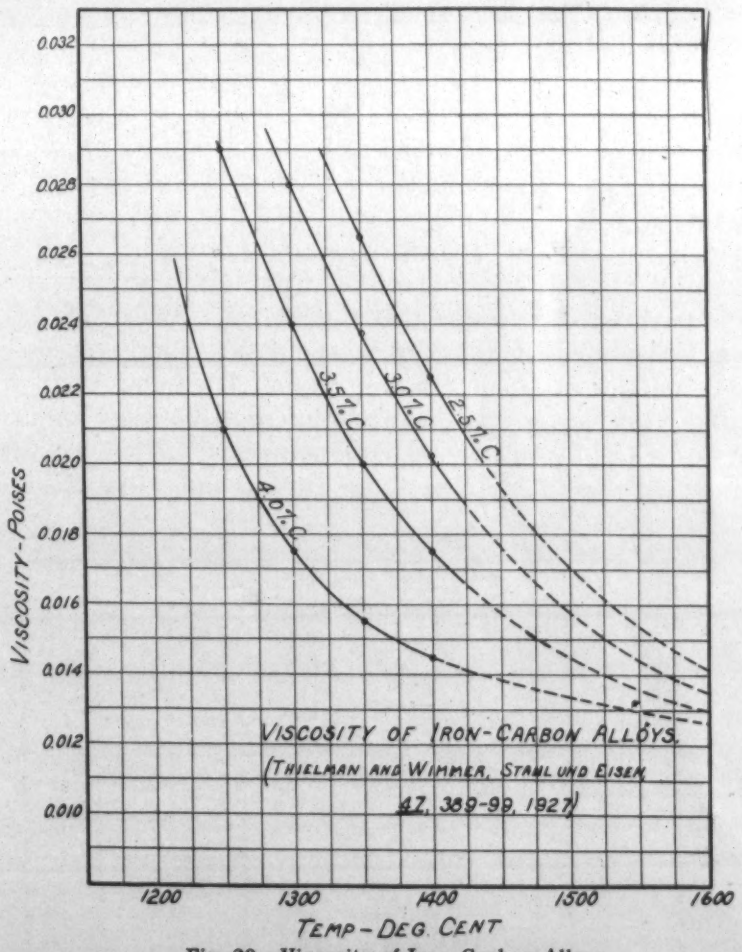



Fig. 20—Viscosity of Iron-Carbon Alloys

course, uncertain, but at least indicates that pure iron (or 0.1–0.2% carbon steel) would probably have a viscosity around 0.015–0.020 poises at 1600°. We assume the value 0.017 for purposes of calculation.

Values[42] of 6.95, 6.94, 7.41, 7.099, 6.88 and 6.92 are given

[40] Shibata, Z., The Equilibrium Diagram of the FeS–MnS System. *Technical Reports, Tohoku Imperial University*, Vol. 7, No. 4 (1928), pages 291–298.

[41] Thielman, H., & Wimmer, A., Ueber die innere Reibung von flüssigem Roheisen. *Stahl und Eisen*, Vol. 47 (1927), pages 389–399.

[42] Benedicks, C., Berlin, D. W., & Phragmen, G., Density of Liquid Iron. *Iron & Steel Institute, Carnegie Scholarship Memoirs*, Vol. 13 (1924), pages 129–174; Roberts, W. C., & Wrightson, T., De la Densité de Certains Métaux a l'Etat Liquide. *Annales de Chimie et de Physique*, Series 5, Vol. 30 (1883), pages 274–288; Berlin, D. W., Some Determinations of the Specific Gravity of Iron and Low Carbon Steel in a Molten Condition. *Iron & Steel Institute, Carnegie Scholarship Memoirs*, Vol. 15 (1926), pages 1–15; Ralston, O. C., Iron Oxide Reduction Equilibria. *Bulletin* 296, *U. S. Bureau of Mines* (1929).

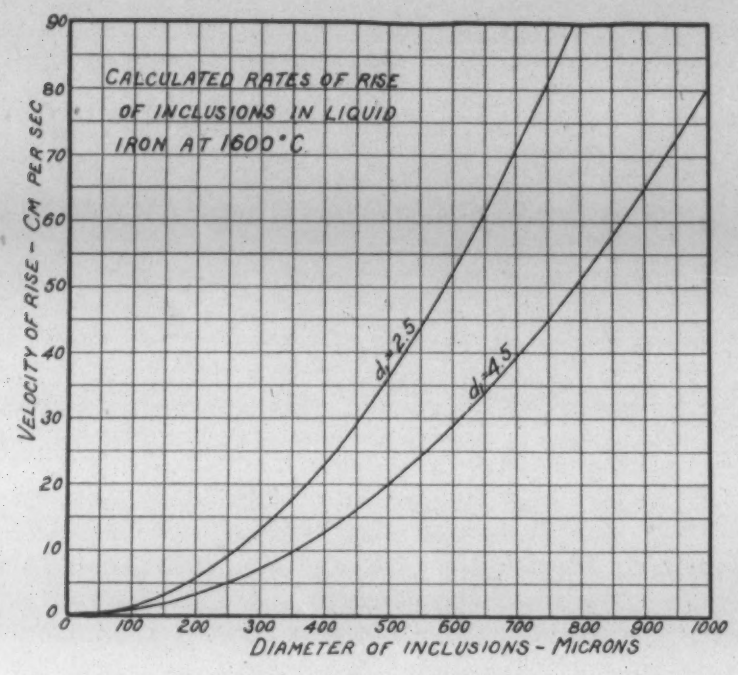



Fig. 21—Calculated Rates of Rise of Inclusions in Liquid Iron at 1600° C.

for the density of molten iron, and we have here assumed the figure 7.0, which is probably not in error by more than 2–4% of the true value.

The densities of the common inclusions range from a minimum of about 2.2 for high-silica glassy inclusions to a maximum of around 5.0–5.5 (no good data available) for those of MnO and FeO. Particles with a diameter as large as 1 mm. (1000 microns) have been observed in very rare instances in steel, while particles as small as 0.001 mm. (1 micron) are often observed.

On this basis, the calculated rising rates for inclusions of two different densities (2.5 and 4.5) are given in centimeters per second in Fig. 21. Particles of 100 microns diam. should rise about 60 cm. per minute and those of 300 microns diameters from 425 – 780 cm. per minute. The more important range of smaller sized inclusions (0–50 microns diam.) is shown by Fig. 22, which gives the time in minutes required for a particle to rise one meter distance. A particle of 1 micron diameter should require about 200 hours; one of 5 microns diameter about 8 hours; one of 20 microns diameter around 30 minutes; and one of 40 microns diameter about 7 minutes. The turbulence which always exists to some extent in practice should increase these values, since the effect of

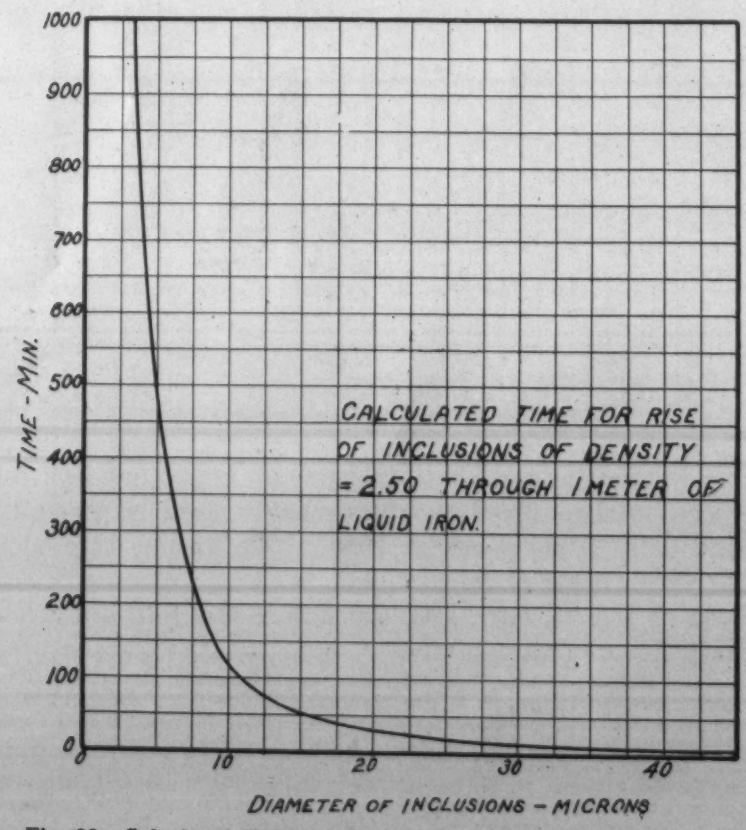



Fig. 22—Calculated Time for Rise of Inclusions of Density = 2.50 through 1 Meter of Liquid Iron

convection currents would be to carry more particles downward than upward as soon as these become more concentrated in the upper layers of iron. The approximate accuracy of the calculated values is favored by the fact that the radius of the particle is the most important variable and the one which is most easily measured.

If the values found for rising velocities are approximately correct, then inclusions larger than around 200–250 microns, when present in steel, must have been held in the liquid by downward-sweeping convection currents, and must have been trapped by crystal dendrites during freezing. Perhaps the best method of approximately checking these results would be to measure the inclusions sizes present in samples taken from the stream of metal from the ladle on the pouring platform. Preferably these should be taken during the pouring of a large ingot which requires all or most of the iron in one ladle, measuring the approximate rate of fall of the metal, progressive change in maximum inclusion, size, etc. Such results would be rough at best, but in view of the difficulties involved might be as good as could be obtained in a laboratory study.

### *Rise of Inclusions from Metal into Slag Layer*

Whenever in a steel-making furnace a deoxidizing metal or alloy is added to the bath containing dissolved FeO, insoluble non-metallics are precipitated in the metal and begin to rise toward the slag. If the simplest possible conditions existed, i. e., perfectly quiet slag and metal and a zero resistance to transfer at the slag-metal interface, the rate of elimination of particles of any given size and density could probably be ascertained rather closely by calculations such as those given in the preceding section. Several disturbing elements enter in, however, to make the problem more complex.

(1) Convection currents in the bath, caused by temperature gradients or gas evolution in the metal, nearly always exist. These would tend to oppose the rise of inclusions upward and might in this way interfere with their elimination. It is quite possible, however, that the effect of gas bubbles or currents in sweeping the inclusions upward to the slag metal interface may more than overbalance the other effect.

(2) There may well be a definite resistance to the passage of inclusions across the boundary between slag and metal. After a particle reaches this boundary, if it is not quickly absorbed into the slag, it is likely to be swept away again into the body of the metal by convection currents either normally present or caused by the stirring effects of tapping the furnace. Solid or highly viscous liquid inclusions would be absorbed more slowly than liquid inclusions of low viscosity. Inclusions which have a lower surface tension relative to iron than the slag should tend to flatten out along the slag-metal interface and so be more quickly absorbed by the slag; drops having a higher surface tension than the slag should tend to remain spherical, and, touching the slag only over a small area, might be absorbed much more slowly.

## XIII. Microscopic Identification of Inclusions

Undoubtedly, the most satisfactory method of identification for inclusions is to dissolve away the metal matrix and make a chemical analysis of the non-metallic residues. However, the discussion in the following section of methods for extracting inclusions from the matrix of carbides and ferrite in steels indicates that all such extraction methods tend to be difficult and time-consuming and do not always give satisfactory results. Identification methods applied to inclusions in polished surfaces under a microscope can be carried out much more easily and quickly. Several investigators have worked out schemes for identifying inclusions by such methods. Wohrman,[19] and Campbell and Comstock[43] have given such schemes and Sauveur[44] has also summarized a number of similar

[43] Campbell & Comstock, Determination of Inclusions in Steel. *Proceedings American Society for Testing Materials*, Vol. 23 (1923), page 522.

[44] Sauveur, A., The Metallography and Heat Treatment of Iron and Steel. 3rd Ed. (1926), pages 512–15, McGraw-Hill Book Co.

methods. They depend chiefly on color, form and resistance to etching reagents; all inclusions being divided roughly into classes, such as sulphides, oxides and silicates. Even at the present stage of development, they have some value in discriminating roughly between extreme types, such as $Al_2O_3$ and silicates, or MnS–FeS and FeO–MnO mixtures, but in most cases cannot be depended upon for absolute identification. In most of the work done on identification of inclusions, the samples studied have been either commercial steels containing many different impurities in the same sample, or synthetic melts made up with slightly impure iron as the raw material. For example, the duplex structures observed in supposedly pure FeO-MnO inclusions may easily have been caused by small amounts of silica or sulphur in the melts. Also, the types of inclusions have been arbitrarily simplified. Pure FeO inclusions rarely occur in commercial steels. So-called MnO inclusions are always mixtures of MnO and FeO, and may contain sulphides or silicates. MnS inclusions probably always contain some FeS, and in nearly all cases manganese silicate inclusions must contain more or less iron silicate. Alumina inclusions very probably contain small amounts of FeO. It is doubtful that titanium oxide or chromium oxide inclusions ever occur free from considerable amounts of FeO or $SiO_2$.

Progress in the more exact identification of inclusions will be largely dependent upon detailed studies of the equilibria in the various oxide and sulphide systems involved, correlated with a study of pure iron-oxygen and iron-sulphur melts treated with various single deoxidizing elements and pairs of such elements. This should include the petrographic study of both oxide melts and extracted inclusions and of polished metal sections with the polarizing microscope used in the study of ores and slags. Unless the whole problem is considered worthy of study in some such comprehensive manner, it probably should be left alone. A procedure such as that of Wohrman serves as a rough indication of the principal deoxidizers used, and of the form and size, and approximately of the number and the mode of distribution, of the non-metallic particles. For the user of finished steel such information is about all that is necessary. The steelmaker, however, who needs thoroughly to understand and control the various oxidation and desulphurization processes, could make good use of a more comprehensive and detailed system of identification.

Some of the methods used by Schneiderhoehn[45] for the examination of polished surfaces of ores and rocks may be used to advantage in developing more accurate methods of identification. In addition to color, form and etching effects, such properties as hardness, reflecting power approximate indices of refraction, and appearance in both ordinary light and in polarized light with crossed nicols, etc., may be used.

For example, in transparent or translucent substances, differing in appearance only in varying degrees of whiteness or blackness (such as the various FeO–$SiO_2$ inclusions, see Section IV), the amount of light reflected at a polished surface depends chiefly upon the index of refraction of the substance relative to air (or the immersion liquid, if an oil immersion lens is used). In slightly transparent or opaque substances, the brightness depends chiefly on the character of the surface as regards light reflection or absorption. Generally, the greater the density of a mineral, the larger its refractive index, and in most cases the greater its reflecting power at a polished surface if it is an opaque mineral. Metallic iron has a higher density than any of the oxides or sulphides which occur as inclusions, and is a good reflector in polished surfaces. In polished, unetched sections, all the non-metallic inclusions appear more or less gray or black (or colored) in contrast to the brilliant white matrix of iron. FeO is probably closest to iron in reflecting power, being opaque and having a high density (around 5.9) and the tiny FeO globules appear very light gray, with only slight contrast to the bright metal background. With increasing MnO contents, the color probably darkens slightly but the change is almost too slight to be noticeable to the eye. In the FeO–$SiO_2$ series, fayalite is nearly transparent, has a lower density (4.3) than FeO and refractive indices around 1.85, and silica glass has a refractive index of 1.46 and a density of 2.19. Accordingly, in the FeO-rich inclusions, the excess FeO appears very light gray in contrast to the darker FeO-fayalite eutectic. In the intermediate types, excess fayalite appears light gray and excess $SiO_2$ dark gray to black in contrast to the fayalite-silica eutectic.

[45] Schneiderhoehn, H., Anleitung zur Mikroskopischen Bestimmung von Eisen und Aufbereitungsprodulsten, besonders im Auffallenden Licht, herausgegeben im Auftrag des Fachauschusses für Erzaufbereitung der Gesellschaft Deutscher Metallhütten und Bergleute," e. V. Berlin (1922).

(*To be Concluded in November*)

## Production of Slab Zinc and Rolled Zinc in 1929

The production of slab zinc at zinc reduction plants in the United States in 1929 amounted to 671,868 short tons, valued at $88,687,000, according to statistics compiled by the United States Bureau of Mines, Department of Commerce. This production consisted of 611,209 tons of primary metal made from domestic ore; 13,311 tons of primary metal made from Mexican ore; and 47,348 tons of redistilled secondary metal. The production in 1929 was 20,621 tons larger than the production in 1928, or over 3%.

The States having the largest output of primary metal were: Montana, with 139,510 tons; Oklahoma, with 111,683 tons; Illinois, with 110,007 tons; and Pennsylvania, with 108,167 tons. The production for Montana is all electrolytic zinc and includes a small quantity of electrolytic zinc from Illinois. The remainder of the output was smelted in Arkansas, Idaho, Indiana, Kansas, Texas and West Virginia.

The apparent consumption of primary zinc in the United States in 1929 amounted to 564,000 tons, a decrease of 14,000 tons from the apparent consumption in 1928.

Rolled zinc produced in the United States in 1929 amounted to 136,667,203 lbs, valued at $12,105,177. These figures, which were compiled from reports made by producers to the Bureau of Mines, show a drop of 7% in quantity and 2% in value of output, as compared with 1928. All classes of rolled zinc showed decreases in production in 1929. Total exports of rolled zinc increased 22%.

The average selling value of rolled zinc was 8.9 cents/lb. in 1929, compared with an average selling value of 8.4 cents in 1928.

## Alloy Steel Producers in Pooled Selling Arrangement

The associated Alloy Steel Company was organized in February, 1930, by the Ludlum Steel Company, the Sharon Steel Hoop Company, and the Timken Steel and Tube Company, to handle those alloy products, manufactured by these companies, which are resistant to heat, abrasion and corrosion.

Each company produces a fairly distinct line of steel products which are sold to machinery manufacturers, fabricators and foundries. The Sharon Company manufactures strip and sheet metal, the Timken Company manufactures tubes and bars, while the Ludlum Company manufactures bars and wire. The only part of the output of these mills that will be sold through the Associated Alloy Steel Company will be those mill forms made of special alloys like Nitralloy, Nirosta and stainless steel; and these constitute only a small part of the products of the three companies.

Although there is a little overlapping in the mill forms sold by the three companies, it is thought that this will not present any great difficulty in the projected selling work, since these are for the most part non-competitive.

It is understood that offices will be opened by the new organization in key cities. The offices now being maintained by the three member companies will continue to handle sales of products other than those involved in the coöperative arrangement. Salesmen are specially trained in the Ludlum plant, which, until now, has been the only one of three companies making these alloys. It is considered necessary to have specially trained salesmen to handle these products, since it is reported that salesmen who can sell tool steels satisfactorily, are frequently ill-equipped to sell alloy steels.

# Battelle Memorial Institute

## A Unique Metallurgical Research Laboratory

By R. Rimbach*

There is a new metallurgical research laboratory in Columbus, Ohio, which any metallurgist would be interested in visiting. This is Battelle Memorial Institute, established by the will of Gordon Battelle, who was interested in, and connected with, industries dealing with metals and fuels, and became convinced that increased scientific research along those lines would be a benefit to mankind, and that the affording of facilities for research would be an effective way of perpetuating the family name.

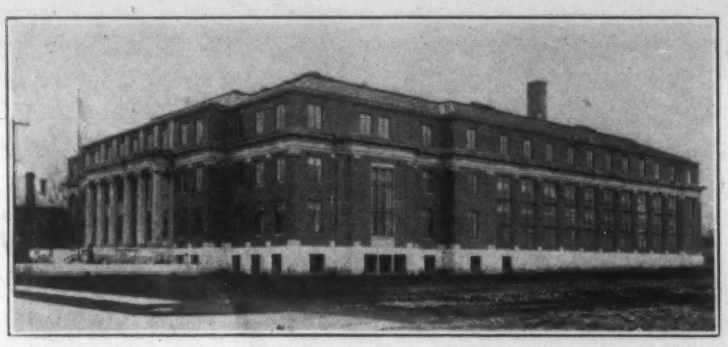


Fig. 1—The Institute Building

This conviction resulted in a unique foundation, unique in that not only does the endowment provide for the carrying on of pure research, science for science's sake, much as is done in university and government laboratories, but it also provides for industrial research.

In the latter line of activity, the Institute functions much like a commercial consulting laboratory, in that it works on specific problems sponsored by industry, the results of which belong to the sponsor, but it differs in that it does no routine analysis or testing, and takes on only truly research problems. It differs too, in that being an endowed institution, incorporated under Ohio laws as an institution not for profit, it does not seek to make a profit on the industrial work, though, of course, the industrial projects are self-supporting in that the actual expenses are reimbursed by the sponsor. The availability of much modern equipment and of space suitable for research makes the actual costs low, considering the caliber of the men to whom the industrial projects are assigned and the supervisory talent which guides them.

The Institute believes that the most effective research is done by mature men who have already finished their undergraduate technical studies, and in many cases have had graduate training so that work at the Institute is not done by part-time workers with their attention chiefly fixed on scholastic work and the getting of a degree. Some of the staff are taking advantage of the proximity to and coöperation with Ohio State University to take advanced work there, but the amount of this is kept to the point where it serves as a stimulus rather than a distraction from the man's main object, his research work at the Institute. Few research laboratories, institutional or commercial, show such a high proportion of well-trained and experienced research men on the staff.

The Institute is unique in its specialization. It deals with metallurgy and fuels, its staff, library and equipment being chosen to meet the needs in those fields of research.

* Associate Editor.

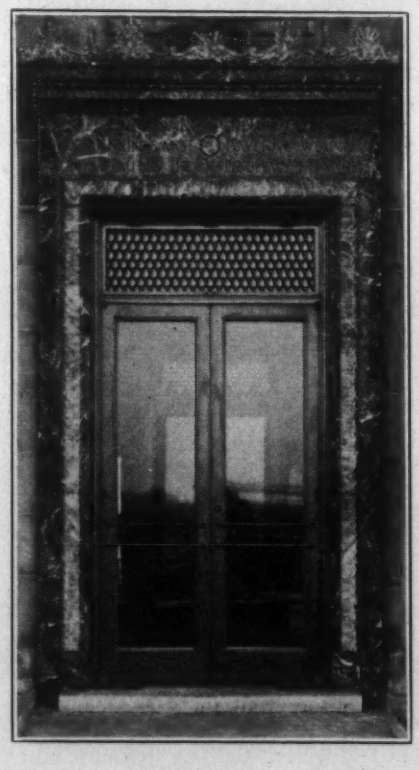


Fig. 2—The Entrance

The building was completed last fall, and is modern and up-to-date in every respect, combining the good features of many laboratories which were studied by the architect and trustees during the design of the laboratory.

Technical operation, that is, the assembling of staff and equipment and the initiation of research projects on those carried out on endowment funds, and those sponsored by industry, has been going on for a year, and the visitor can now get a pretty accurate idea of what the Institute is going to be.

The first project sponsored by industry to be taken on by the Institute staff was coöperation in the editorial work on METALS & ALLOYS, the aims of a "journal of engineering metallurgy" being practically coincident with those of the Institute, and an account of the laboratory and its activities may, therefore, be of special interest to our readers.

As the visitor approaches the Institute, he notes the open, uncrowded location across the street from the athletic field of Ohio State University, facing the Stadium, with a municipal recreation ground on one side, a residential district on the other, and vacant lots, owned by the Institute and reserved for future expansion, in the rear. He notes the large, well-kept lawn, and as he enters the building itself, his first impression is one of dignity. The exterior is not ornate, the brick and limestone construction giving a feeling of solidity and spaciousness, of suitability for its purpose, with due attention to appearance.

Most visitors, as they enter the marble-walled lobby, with its bronze fixtures, are surprised at the architectural treatment which is unusual in a research laboratory, and as they go through the library, with its tall windows, its attractive woodwork, its rugs and hangings, and the Trustees' Room

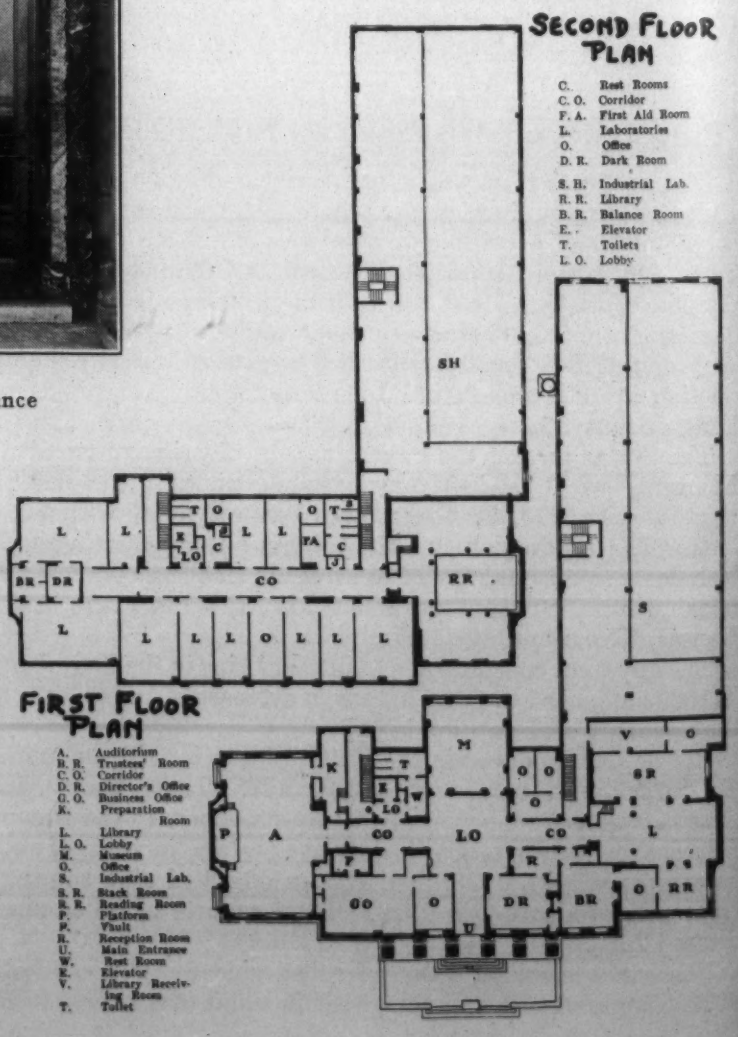


Fig. 3—The Lobby—Portrait of Col. Battelle, Gordon Battelle's Father

Fig. 5—The Trustees' Room—Portrait of Gordon Battelle

with its richly paneled walls (a reproduction of Gordon Battelle's office, and containing his office furniture), they are struck by the beauty and spaciousness of these memorial parts of the building. One can but feel that here is one place where the value and dignity of research has been appreciated, and that the staff has a very pleasant environment in which to work.

As one passes through the laboratories themselves, he notes that they are light, airy, roomy and well equipped for the purposes of the Institute's specialties.

While there is still much unused space available for future expansion since at least 200 workers can be comfortably accommodated, and the present staff numbers something over 50, yet one feels that to assemble that staff, provide adequate equipment for its use, and get it started at work on active research projects within the first year, is at least a respectable accomplishment.

The building is constructed in the form of an "L," with approximate dimensions of 160 feet by 200 feet, and provides some 90,000 sq. ft. of floor space, well designed and well arranged for research purposes. A general view of the building is shown in Fig. 1, and a detailed view of the entrance is shown in Fig. 2. The architecture is Roman-Ionic, and the construction is of brick and limestone.

The ideal of the Institute is told by the legend over the front door: "Original Research is Mankind's Most Powerful Weapon in Solving the Problems of Nature."

At the east end of the lobby is located the auditorium, which has a seating capacity of approximately 150 persons, and which is used as a meeting place for the staff and for other technical and scientific groups. The auditorium is equipped with a small stage, motion picture projection booth, and experimental demonstrating apparatus.

The west end of the front part of the building is occupied by the library. The library has 3000 sq. ft. of floor space on the first floor, and nearly the same amount on the second floor.

Because of the fields of work covered by the Institute's activities, the library is specialized. It now consists of over 2,000 volumes, and is rapidly being increased. Over 110 current periodicals are received by the library. One of the valuable features of the library is the index of current literature, which now has over 85,000 in the metallurgical field alone, thus making information readily and quickly findable. Keeping this index up to date is one of the important duties of the experienced librarian in charge.

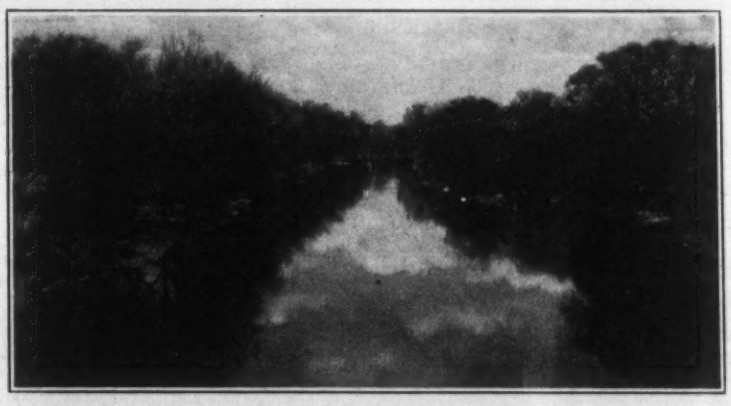


Fig. 6—The Olentangy River, a Beauty Spot Half a Block from the Institute

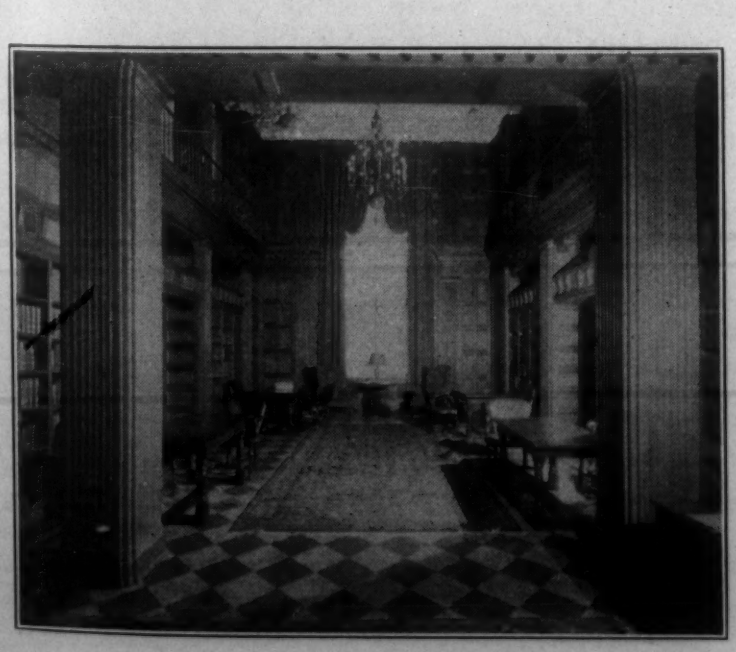


Fig. 4—The Library

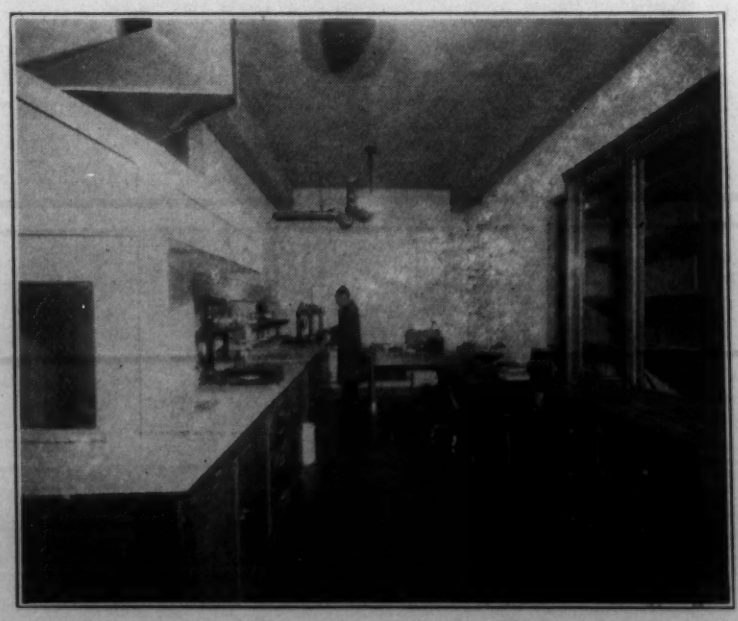


Fig. 7—One of the Individual Laboratories on Sponsored Projects

Fig. 8—Machine Shop

The Institute's library has been so selected that in utility it compares favorably with many of the older and larger libraries. It is being recognized and used by investigators, other than those on the Institute's staff. The utility of the library is increased by the fact that books and periodicals are bound in the Institute's own bindery, and thus are available for reference at all times.

The basement floor is occupied by a well equipped machine shop, the bindery, constant temperature room, vault, storage and stock room, grinding, pulverizing and sampling rooms. The machine shop is, of course, one of the most useful parts in the Institute, as the building of special equipment and instruments is constantly required. The superintendent in

Fig. 9—The Institute Staff, July 1, 1930

charge has had long experience in shop work for metallurgical research, and appreciates, as the ordinary mechanic seldom does, that specimens must not be mixed up, markings left off, or instruction as to finish disregarded.

The storeroom now has listed on the inventory over 6,000 items and is in charge of a competent storekeeper, thus making the usual miscellaneous supplies and apparatus readily available.

The second floor of the front of the building is occupied by reading rooms and stocks of the library, and by a series of laboratories, some of which are arranged for group work, while others are individual laboratories of approximately

Fig. 11—Switchboard and Storage Batteries

12 x 22 feet. Each laboratory is equipped with tables, sinks and hoods, all of which have been designed to afford maximum flexibility. Each table is supplied with hot and cold water, gas, vacuum, compressed air, steam, direct and alternating current. A notable feature is the ventilating hood which is a separate unit in itself, being connected with a stoneware duct system running directly to the roof with forced draft, actuated by an individual motor with an indicating light over each hood.

On this floor are also located the special analytical, physical and metallographic laboratories. These laboratories are especially equipped for work on metals, fuels and related problems, and function in part as service departments for the various researches.

The third floor is occupied by research laboratories of the group and individual types, and has about 18,000 sq. ft. of floor space.

The third floor of the south wing of the building may, when required, be partitioned off into still other individual research laboratories. The remaining space, including the basement, first and second floors, contains the industrial laboratory, which has a clearance of thirty-five feet with balconies on the first and second floors. This large laboratory (30′ x 130′ x 36′ high) is designed for large scale or semi-plant operations. It is provided with a five-ton overhead electric crane. The balconies are used for mechanical testing equipment, heat treating equipment, etc. The mechanical testing equipment for tension, compression, transverse, impact, wear, fatigue, pounding, hardness, tests at high and low temperature, long time creep tests at high temperature, etc., is modern, and has been specially selected or built for research work.

The heat-treating department has been provided with a battery of furnaces, mostly electric, with full pyrometric equipment and auxiliary control devices.

In the fuel line, equipment is already in or is being ordered for use in the study of fundamentals of the combustion of pulverized fuel and other problems. Many types of gravity,

Fig. 10—Carpenter and Pattern Shop

Fig. 12—The Heat-Treatment Laboratory

Fig. 13—Corner of the Foundry

concentration, flotation, magnetic and other types of equipment are already installed or being ordered for the work on ore beneficiation. Some grinding and pulverizing equipment for both ores and fuels has been installed, and additional equipment has been ordered.

The industrial laboratory contains a well equipped foundry with electric and other types of melting furnaces. Additional equipment of various kinds is being added as requirements develop in the research program.

The tract of land back of the present building provides for further expansion, such as the erection of pilot plants, or semi-commercial scale units for extended study of research projects.

*The Technical Staff.*—During the first year, the technical staff has grown from four to more than thirty, and the whole personnel from seven to more than fifty. The technical staff has been assembled from government, industrial and educational institutions, and represents some forty college degrees taken at twenty-one different institutions.

G. B. Fenton, Business Manager, Dr. H. W. Gillett, Director, C. E. Williams and Dr. O. E. Harder, Assistant Directors, are the executives.

The older technical, or leader group, responsible for planning technical work under executive guidance, consists of C. E. Irion, Physical Chemist and Superintendent of Building; Dr. H. W. Russell, Physicist; W. A. Welcker, Jr., Mechanical Engineer; Dr. M. Benoy, Analytical Chemist; J. L. Gregg, Metallurgist; H. C. Cross, Metallurgist; R. A. Sherman, Combustion Engineer; F. L. Hobart, Fuel Engineer; Dr. C. H. Lorig, Metallurgist; B. M. Bird, Concentration Engineer; Dr. H. E. Simpson, Ceramic Engineer; L. H. Grenell, Metallurgist and S. Epstein, Metallurgist. All these have had training and post-graduate experience in research at least equal to the possession of a doctor's degree. (The names are given in the order in which they reported for duty at the Institute.)

The younger technical group, working under the direction of the older men, consists of over a dozen technical graduates, several of them with master's degrees, or considerable research and commercial experience.

*Researches in Progress.*—The number of research projects

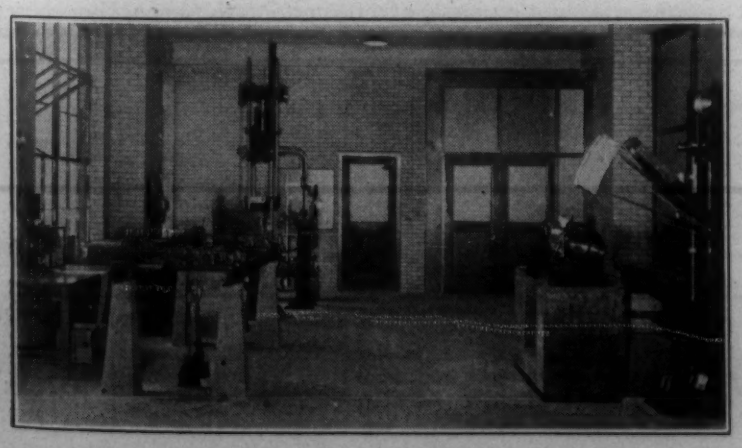


Fig. 14—Mechanical Testing Laboratory

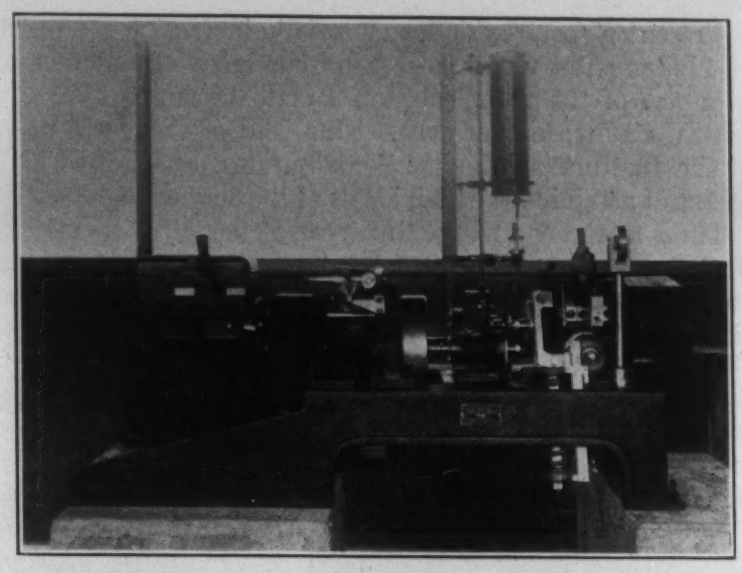


Fig. 15—Amsler Wear-Testing Machine, Used in the Study of Bearing Metals

which could be gotten under way during the first year has been limited by the amount of time and effort required in securing and installing equipment, and because many embers of the staff have only recently reported for active work.

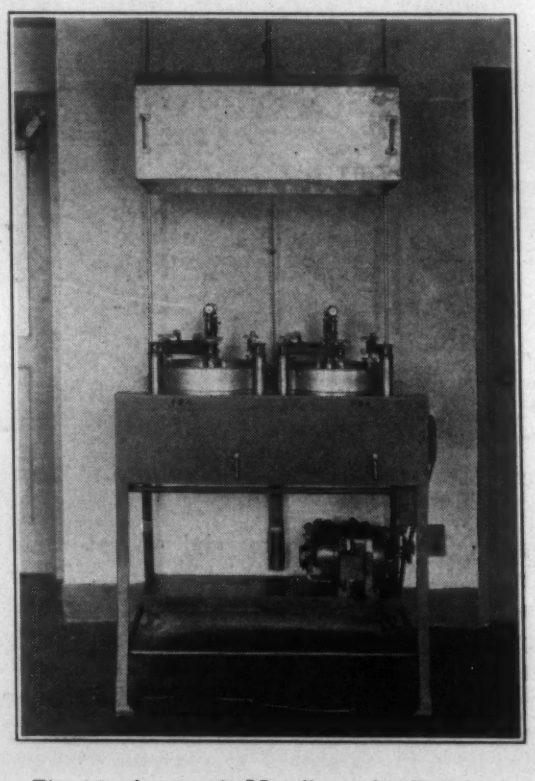


Fig. 16—Automatic Metallographic Polishing Equipment

However, at the end of the first year, active work is in progress on six projects provided for by Institute funds, four coöperative researches, which are partly provided for by Institute funds, and ten researches sponsored by industry. Four of the ten sponsored projects are of the multiple fellowship type.

Fig. 17—Crushing and Sampling Room

Present plans provide for materially increasing the number of fundamental researches to be conducted by the various members of the technical staff and to be supported by the Institute's own endowment. This field of work will be one of the Institute's principal contributions, and is one of the means of attaining the high ideals of the endowment.

Thus, at the end of the first year of technical operation of Battelle Memorial Institute, an unusually attractive and well arranged building has been finished and equipped. A technical staff of men specially trained for research work in the two major lines, metals and fuels, has been assembled and organized; both fundamental and sponsored researches are in progress. The sponsored projects may be considered to have made an excellent start, considering the newness of the Institute.

The Institute has had a very favorable reception by other research organizations and by industry, and the prospects are very bright for the accomplishment of the worthy and unique ideals conceived and provided for by Gordon Battelle.

Six of the major projects which are being supported in whole or in part by Institute funds are given below:

1. Low temperature properties of aircraft materials.
2. Centrifugal methods of metallurgical analysis.
3. Combustion of pulverized fuel.
4. Alloys of iron research. (Codification of known information and preparation of monographs.) Coöperative with Engineering Foundation and ten technical societies.
5. Low temperature carbonization of coal. Coöperative with the Engineering Experiment Station of Ohio State University.
6. Effect of coal ash on refractory bricks. Coöperative with the American Society of Mechanical Engineers and the U. S. Bureau of Standards.

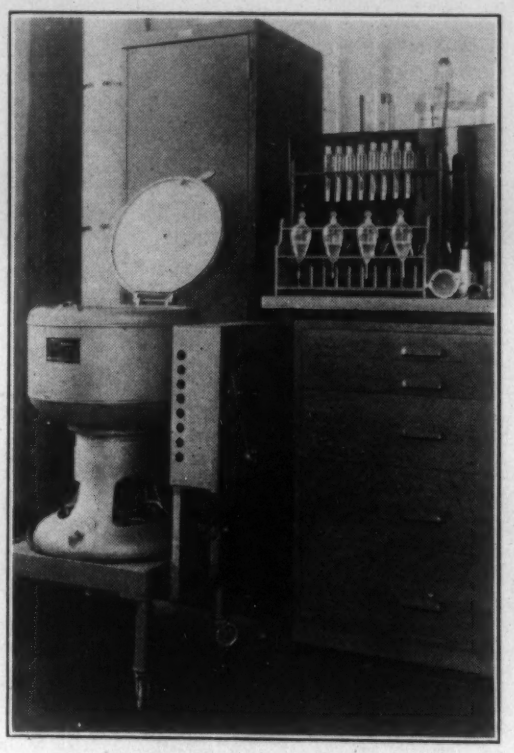


Fig. 18—Large Centrifuge, Used in Analytical Research Problems

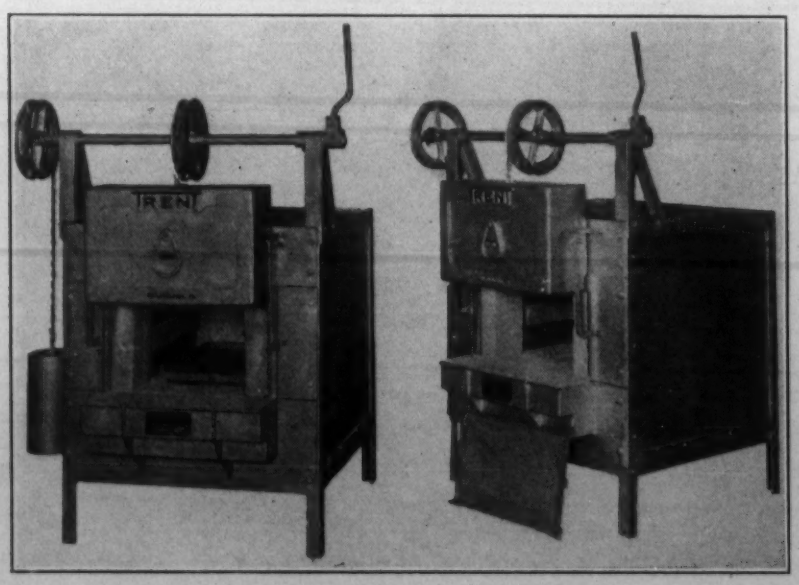
The following projects sponsored by industry are in progress:

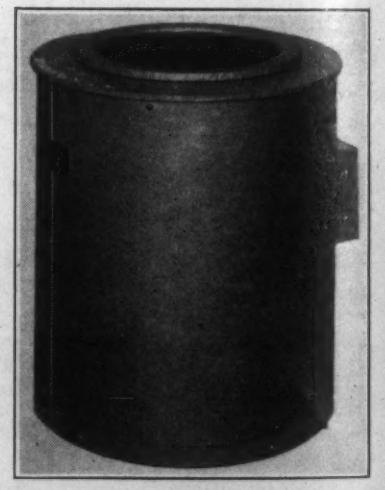
1. Editorial work on METALS & ALLOYS.
2. Researches on metal roofing materials.
3. Researches on thermal properties of metals.
4. Research on alloys for the production of thin metal sheets.
5. Special developments for the use of metal foil.
6. Research on bearing metals.
7. Research on cast irons.
8. Research on beneficiation of low-grade iron ores.
9. Endurance properties of special steels.
10. Study of embrittlement of structural steel in galvanizing.

## Two New Electric Furnaces Suitable for Experimental Work

To meet the demand of commercial laboratories and technical schools for an electric furnace quickly responsive to a changing work program, the Harold E. Trent Company, of Philadelphia, are offering a junior model of their larger heavy duty type. The main difference is to be found in lighter mechanical construction. However, where hard blows are to be expected—on the hearth and against the platform before the door—plenty of extra strength has been incorporated as may be seen in the illustrations.

An interesting example in simplification is the method of drawing the doors tight against the furnace fronts. A pin on the door casting engages a bar that slopes in toward the furnace front about half-way down of the opening. The doors are nicely counterbalanced so that they may be operated by one hand on a lever not over a foot long. Heating elements of the strip type but continuously folded and formed are reported to be exceptionally long-lived due to the absence of sharp points or corners. At 1850° F., the 8″ × 6″ × 12″ size uses 4.5 kw. at 220 volts, single phase, or 110 volts, 3 phase.



For the quick melting of salt baths, soft alloys and similar work, the same company has devised a new type of pot furnace. Like the direct-heat type described above, it is heated with continuously folded and formed metal ribbons which are free from sharp corners. Due to this fact, they are said to be free from deformation—thus enabling them to be placed within $1^1/_4$″ of the outside walls of the one-piece, pressed steel pots. A further factor toward decreased outside diameter of casings is the use of a wall material combining both refractory and insulating properties.

The DB-1416 type is 14″ in diameter of pot by 16″ deep. On 220 volts, single phase, or 110 volts, two phase, the connected load is 11.5 kw. Terminals are at the back in a splash-proof case with leads arranged so that they cannot be loosened accidentally. Other sizes are in preparation.

## Brands of Refractories

Under this title the American Refractories Institute, Oliver Bldg., Pittsburgh, Pa., has issued a 70-page booklet which lists every known manufacturer of fire brick in the United States and Canada, together with a list of the brand names of their products. The brand names are arranged alphabetically and are followed by an alphabetical list of manufacturers of refractories, giving brands and plant and principal office locations. There is a further classification of plants by geographic location. Those interested may obtain copies at 25 cents each, addressing the secretary of the institute at the address given.

# The Heat Treatment of Aluminum Alloys†

By Robert J. Anderson*

(*Continued from September*)

## Factors Affecting Results

In heat treating aluminum-alloy products, the chief factors for consideration are the following:

(1) Chemical composition of the alloy.
(2) Mechanical or physical properties to be met.
(3) Physical condition of the material, as affected by the method of manufacture.
(4) Microstructural features, including grain size, homogeneity, coring and distribution and nature of microscopic constituents.
(5) Presence or absence of defects, e. g., inclusions, porosity, shrinkage cavities, laminations, seams, dissolved gases, columnar structures, etc.
(6) Time period of soaking at the proper elevated temperature prior to the quench.
(7) Temperature of soaking prior to the quench.
(8) Quenching temperature, i. e., the temperature when the part strikes the quenching bath, as governed not only by the soaking temperature but also by the rapidity of transfer from the heating furnace to the bath.
(9) Nature of the quenching medium.
(10) Temperature of the quenching bath.
(11) Time period of aging at a given temperature after the quench.
(12) Temperature of aging after the quench.
(13) Suitability of furnace and oven equipment, particularly as to control of temperature and temperature distribution.
(14) Equipment for handling parts both in and out of the soaking furnace and the aging oven.
(15) Size, weight, shape and section thickness of parts, especially as regards distortion on heating for the quench, internal stresses set up on quenching, and the mass effect.

Adequate technical control will take care of variations in most of the above items. Some of the others are not readily susceptible to control or are matters dependent upon the skill and judgment of men experienced in design or shop practice. It should be emphasized that for satisfactory results the heat treatment of aluminum-alloy manufactures must be carried out on a strictly scientific basis from start to finish. Not only must the actual heat-treatment processes be performed by scientific methods, but it is of equal importance that the production of castings or wrought parts be under a high degree of technical supervision and control. While detailed discussion of the items above listed cannot be given here, the chief points of note may be stressed.

As already mentioned, the aluminum alloys for heat treatment are very sensitive to certain slight changes in chemical composition, and hence there is necessity for close chemical control. Batches of alloys should be made up in large lots from analyzed materials, poured into pigs and analysis made. On a second melting, any required corrections in composition may be made. In all cases, the mechanical or physical properties to be met will be a factor in determining the composition of the alloy and the heat treatment to be employed. Chill castings respond more readily to heat treatment than sand castings, and hence the permanent-mold process is playing an important role in the heat-treatment field. Wrought products, such as sheet or forgings, yield better mechanical properties and respond to heat treatment more quickly than cast manufactures. Large segregate particles of excess substance, e. g., $CuAl_2$, formed in sand castings are much more difficultly soluble than the smaller particles and finer network produced in chill castings, or the fragmented particles found in wrought products. Hence, the time period of heating previous to quenching depends on the physical condition and microstructure of the parts as influenced by the method of manufacture and chemical composition. Regarding the nature of the microscopic constituents in the alloys, it is possible to vary the characteristics and form of certain constituents by variation in the chemical composition, thereby making the alloy more susceptible to heat treatment, e. g., by the formation of a fine or discontinuous network or by filigration as contrasted with the formation of a continuous network structure or coarse segregate particles.

Defects in both wrought and cast manufactures are naturally to be avoided. Heat treatment cannot cure inherent flaws. Hence, more than ordinary care must be given to the manufacture of parts that are to be heat treated. The time period of soaking prior to the quench must be long enough to take into solution all of the soluble material possible if maximum hardening on aging is to be secured. In practice, schedules are set up on the basis of experience, these varying with the type of heating equipment, the thickness of the parts and the weight of the load. Both the soaking temperature and the quenching temperature depend upon various other factors, including the chemical composition of the alloy, shape of the parts and method of handling. In quenching, parts must be handled from the furnace to the quenching tank as rapidly as possible to avoid loss of heat. Different quenching media have different effects on the ultimate properties obtained, and in general the more drastic the quenching, the higher the resultant strength and hardness. Water is being used widely at the present time as the quenching medium. Both the time and temperature of aging are varied depending upon the alloy used, the properties desired and other cognate factors. Roughly, more uniformity of results and better properties are obtainable by aging for a long time at a given moderately elevated temperature, rather than by aging for a short time at some higher temperature. Usually, in practice, the aim is to reduce the aging time as much as possible. Furnace and oven equipment must be capable of accurate control of temperature, and the temperature distribution should be very uniform. Mass effects in heating and quenching aluminum-alloy parts are very important, as in the case of steel. Handling equipment must be of the proper design to avoid marring or otherwise injuring the parts; aluminum alloys are hot short and may crack if bumped or jolted at the quenching temperature.

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* Consulting Metallurgical Engineer, Cleveland, Ohio.

**Table 3**
**Effect of Different Heat Treatments on Some Mechanical Properties of Sand-Cast "Y" Alloys[a]**

| Condition of Test Sample or Heat Treatment | | | | | Mechanical Properties | | |
|---|---|---|---|---|---|---|---|
| Time of Soak, hours | Temperature of Quenching ° C. | Quenching Medium | Time of Aging, Hours | Temperature of Aging, ° C. | Tensile Strength, Lbs./in.² | Elongation in 2 Inches, % | Brinell Hardness, (500 kg., 10 mm.) |
| As sand cast—not heat treated | | | | | 25,000 | 0.7 | 75 |
| Air aged 6 months, after casting | | | | | 28,400 | 0.5 | 96 |
| 5 | 510 | Boiling water | 16 | 100 | 37,000 | 0.5 | 97 |
| 5 | 510 | Boiling water | 2 | 204 | 36,700 | 0.5 | 105 |
| 5 | 510 | Boiling water | 16 | 204 | 39,300 | 0.5 | 105 |
| 4 | 510 | Boiling water | 1 | 232 | 35,400 | 0.5 | 109 |
| 1 | 510 | Boiling water | 30 days | Room temp. | 33,800 | 0.5 | 89 |
| 1 | 510 | Boiling water | Tested immediately | | 29,400 | 1 | 80 |

[a] Tests by Daniels.

As is evident, the various factors listed above are closely related, and a change in one may require some change in another. In practice, a nice adjustment is required among all the inter-related items that have bearing on results.

## Heat-Treatment Schedules

The heat-treatment schedule entails three steps, viz., (1) soaking for a suitable period of time at some selected elevated temperature (2) quenching and (3) aging, either at the ordinary temperature or at a selected somewhat elevated temperature, for a suitable period of time (precipitation treatment). In spheroidizing, for enhancing ductility mainly, the treatment comprises heating for a long time at an elevated temperature, followed by quenching in a liquid or in air; aging is not required. The precise schedule of heat treatment to be applied is dependent chiefly on the items listed as 1, 2, 3 and 15 under the caption "Factors Affecting Results" above. While normally the quenching temperature and time period of soaking are fixed by experiment for given alloys and specific parts, the aging time and temperature are varied to yield different results.

The first step in the heat-treatment schedule is to charge the parts into the heated furnace, say, at about 500° C., and hold for 30 minutes to several hours or more. Soaking temperatures employed for heating prior to the quench lie in the range 480–550° C., with the actual quenching temperatures somewhat below these temperatures due to heat loss in transfer to the quenching bath. An important factor in the solution treatment is the time period of heating prior to the quench. This is very closely dependent on the temperature. Thus, for the sand-cast 96:4 aluminum-copper alloy, heating for 50 hours at 500° C. is not as effective as heating for four hours at 520° C.; when this alloy is chill cast, a soaking period of 2 hours at 520° C. is more effective than of 24 hours at 500° C. The practical upward limit for soaking temperatures is governed by the alloy, distortion and warping that may take place at higher temperatures, and methods of handling. Hence, while it may be desirable to heat for short times at higher temperatures, it may be necessary in practice to use somewhat longer times at lower temperatures. The aim, however, is to shorten the time period of soaking as much as possible. Other factors affecting the time period of soak include the composition of the alloy, method of manufacture of the parts, thickness of section, and mode of heating, i. e., whether in a liquid (molten) salt bath or in a furnace atmosphere. Briefly, the time period of soaking must be long enough and the temperature concomitantly high enough to effect as much solution of soluble constituents as is possible without causing any incipient melting or distortion of the work.

For economic reasons, it is usually desired to avoid protracted heat treatments, and hence a treatment that can be completed in a few hours is used where feasible. Research, together with extensive plant experience, has developed sundry short treatments that give satisfactory results. Thus, a treatment for permanent-mold-cast pistons (made of a special alloy) consists in heating for 1½ hours at 515° C., followed by quenching in water at about 70° C. and then aging for three hours at 220° C. This has the effect of raising the Brinell hardness from 90–140, and at the same time conferring permanent growth. Roughly, the time period of soaking for chill castings may be from 1–12 hours and for sand castings from 4–100 hours. In the case of wrought parts such as sheets, tubes and forgings, the time period of soaking is usually from 30 minutes to 2 hours, longer times being required with heavy sections. The preferred quenching temperature for most wrought alloys of the duralumin type, e. g., 17S, is about 510° C., while 25S and 51S are usually quenched at about 520° C. in plant operation. Some furnace men prefer to overshoot the maximum temperature before charging, thus allowing the charge and container (if any) to absorb heat, thereby lowering the temperature of the furnace. There is danger of overheating or distorting some parts of the charge in this way, and it is more desirable to have the soaking furnace held at the proper temperature before charging. Some specific heat-treatment schedules are given in Table 4 as applied to castings.

Regarding aging after quenching; as already mentioned, some alloys age-harden satisfactorily on standing at the ordinary temperature (so-called natural or spontaneous aging) while others require heating at some slightly elevated temperature (so-called accelerated aging). Some alloys exhibit considerable spontaneous aging effect but the best properties are obtainable only by aging at a moderate temperature. The proper aging time and temperature depend upon the alloy and the properties desired, and the best combination for particular circumstances is worked out experimentally. Some alloys age-harden well at 150° C. but soften if aged at 200° C. In other alloys, if the time at the optimum aging temperature is considerably extended, one mechanical property may be increased at the expense of another. Ordinary duralumin yields better mechanical properties when aged at the ordinary temperature than if heated to some slightly elevated temperature. The effect of the aging temperature on the properties of 17S, 25S and 51S has been indicated in Table 1. The maximum strength is obtained with 25S by heating for 8–15 hours at about 143° C., and with 51S by heating for around 18 hours at about 157° C. Cast alloys are aged at temperatures in the range 20–230° C., and the times vary from, say, a week or more at the ordinary temperature to 8 hours at 150° C. to 3 hours at 215° C.

## Equipment for Heat Treating

Various types of heating furnaces and aging ovens are used in practice for the heat treatment of aluminum-alloy manufactures. Irrespective of the design of the equipment and method of heating, the chief requirements are accuracy of temperature control and uniformity of heat distribution. There are many advantages in the use of electrically-heated equipment, and, in the writer's opinion, these are usually sufficiently attractive to outweigh the higher first cost of installation and higher operating costs.

**Table 4**
**Effect of Heat Treatment on the Tensile Properties of Some Cast Aluminum Alloys[a]**

| Composition of Alloy | Time of Soak, hours | Temperature of Quenching, ° C. | Quenching Medium | Time of Aging, Hours | Temperature of Aging, ° C. | Tensile Strength, Lbs./in.² As Cast | Tensile Strength, Lbs./in.² Heat Treated | Elongation in 2-Inches, % As Cast | Elongation in 2-Inches, % Heat Treated | Brinell Hardness, (500 kg., 10 mm.) As Cast | Brinell Hardness, (500 kg., 10 mm.) Heat Treated |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 Si, 0.4 Fe; sand cast | 96 | 551 | Cold water | 8 | 149 | 18,300 | 20,000 | 8 | 17 | 34 | 32 |
| 5 Cu, 1 Si; sand cast | 24 | 510 | Boiling water | 2 | 149 | 21,500 | 31,000 | 2 | 5 | 60 | 75 |
| 4 Cu, 0.25 Si, 0.4 Fe, 0.5 Mg, 0.75 Mn; sand cast | 5 | 496 | Boiling water | 11 days | Room temp. | 21,000 | 32,000 | 1 | 0.5 | 66 | 93 |
| 1.16 Mg, 1.02 Si; sand cast | 96 | 552 | Cold water | 8 | 149 | 17,900 | 34,100 | 3 | 6.3 | 48 | 65 |
| 4 Cu, 1.5 Mg, 2 Ni; sand cast | 5 | 510 | Boiling water | 16 | 204 | 25,000 | 39,000 | 0.7 | 0.5 | 75 | 105 |
| 2.5 Cu, 0.5 Mg, 1.25 Fe, 0.25 Si; sand cast | 2 | 520 | Boiling water | 2 | 149 | 25,000 | 31,000 | 5 | 3 | 60 | 67 |
| 10 Cu, 1.25 Fe, 0.25 Mg; sand cast | 5 | 496 | Boiling water | 16 | 149 | 26,000 | 35,000 | 1 | 0.5 | 88 | 120 |
| 10 Cu, 1.25 Fe, 0.25 Mg; chill cast | 4 | 510 | Boiling water | 3 | 215 | 27,000 | 40,000 | 1 | 1 | 95 | 160 |
| 2 Cu, 10 Zn, 0.25 Mg; sand cast | 3 | 493 | Boiling water | 3 | 100 | 25,000 | 34,200 | 1.4 | 2 | 60 | 80 |
| 13 Si; chill cast, modified | 2 | 555 | Cold water | Not aged | ... | 31,000 | 30,000 | 6 | 18 | 60 | 58 |
| 4.87 Cu, 0.31 Mg, 0.56 Si, 0.75 Fe; sand cast | 96 | 510 | Cold water | 8 | 149 | 21,000 | 37,000 | 2 | 3 | 60 | 80 |
| 4.87 Cu, 0.31 Mg, 0.56 Si, 0.75 Fe; chill cast | 96 | 510 | Cold water | 8 | 149 | 24,000 | 43,000 | 3 | 6 | 62 | 83 |

[a] Data from various sources (chiefly tests by Daniels and associates at laboratory of U. S. Army Air Service).

In heating for the quench, muffle, semi-muffle and open furnaces heated by electricity, gas and oil are used, as well as the salt bath (composed of equal parts of sodium and potassium nitrates) contained in a steel tank and fired by oil or gas. Uniform distribution of heat and accuracy of temperature control are not so readily obtained in a fuel-fired furnace as in one heated electrically. Even in the electrical-resistance furnace, it is advisable to provide forced circulation of the atmosphere by fans or other suitable means. The electric furnace is well adapted for long soaking periods and continuous methods of heat treatment and is easy to handle. Fig. 11 shows a view of a new type electric-resistance furnace designed especially (by the Gas Equipment Engineering Corp., Philadelphia, Pa.) for heating duralumin-type sheet prior to the quench. The heating elements are nichrome resistance ribbon, and the rating is 135 kw., operation being on a 60 cycle, three-phase line at 220 volts. The furnace is also suitable for the heat treatment of aluminum-alloy castings. A special feature of the set-up is the location of the quenching tank directly beneath the furnace chamber. The charge is handled by means of racks or baskets, lowered and raised by a hoist situated on top of the furnace and driven by an electric motor. Speed of transfer from the heated chamber to the quenching bath is very rapid. The chamber is sealed by a bottom door, shown in place in the illustration. Power operating cost is figured at about 0.14 cents per pound of work treated, with power at 1 cent per kw. (including the demand charge). The capacity is around 500 pounds per hour. Fig. 12 shows a pit type electric resistance furnace used for heat treating pistons and cylinder heads at the plant of the Wright Aeronautical Corp., Paterson, N. J. These two furnaces are of the batch type.

The fused salt bath gives satisfactory heat distribution, when fuel fired, particularly if agitated, since circulation of the bath tends to "iron out" inequalities of temperature; moreover, the salt bath effects rapid heating. However, salt baths have definite disadvantages, being dangerous to handle on account of splashing. Parts heated in salt baths should preferably be quenched in boiling water to facilitate removal of the salt. Air quenching from salt baths is not practical since the salt, if allowed to cool slowly, forms a sort of hard enamel on the parts which is difficult to remove. The nitrate bath may cause exudations to appear on the surface of parts, and aluminum alloys heated in salt

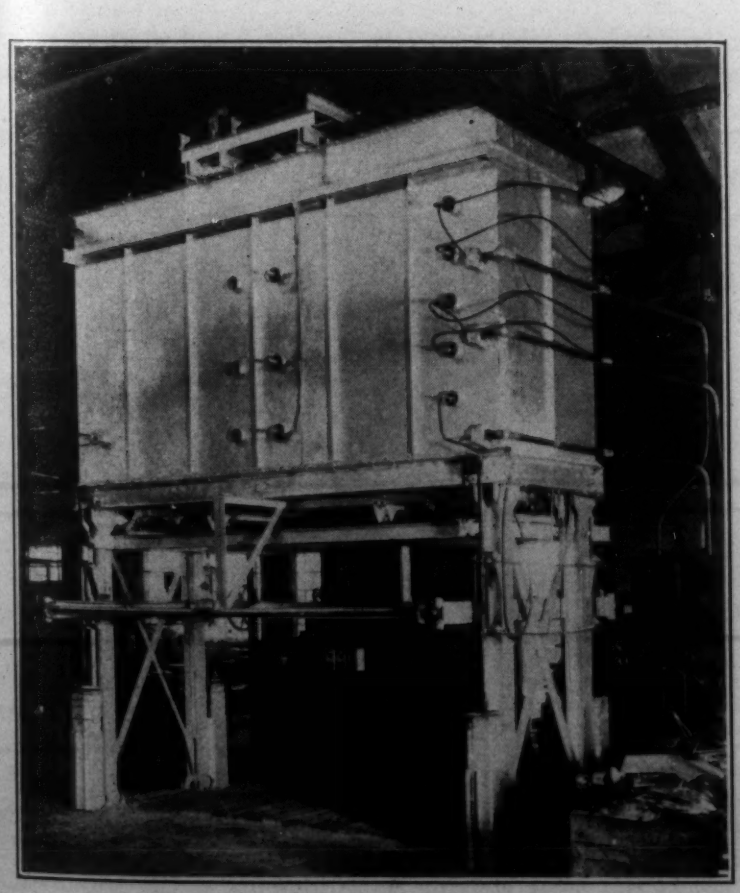

Fig. 11—General View of Electric Heat-Treating Furnace

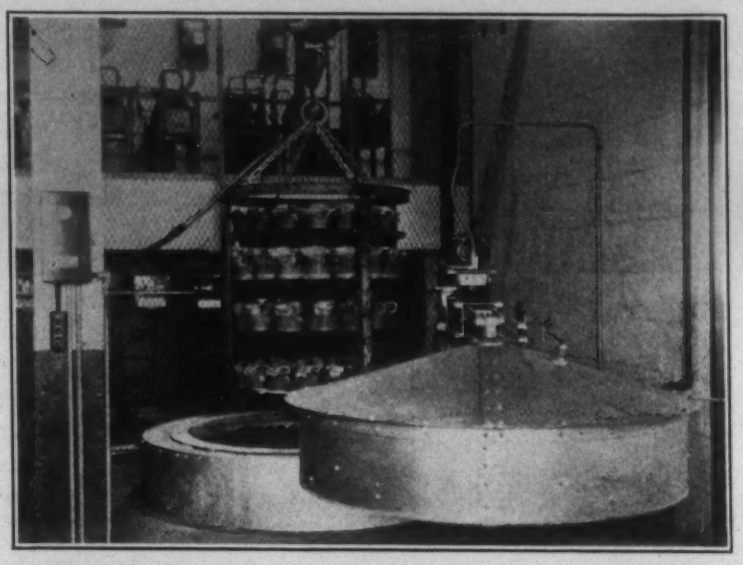

Fig. 12—Pit-Type Electric Furnace (Wright Aeronautical Corp.)

baths appear to be somewhat more susceptible to corrosion than if heated in ordinary furnace atmospheres, particularly if subsequently aged in steam. Gas-fired semi-muffle furnaces are used to some extent but more especially for annealing wrought manufactures.

Quenching is done in cold water, boiling or hot water, oil, an air blast or still air. Hot water is satisfactory for most purposes, but air quenching is necessary for some complicated castings, e. g., cylinder heads, to avoid distortion or the setting up of internal stresses that may subsequently cause trouble on machining. In some cases, castings may be held rigidly in jigs to prevent warping when quenched in water.

Various appliances are used in practice for the aging treatment. In some plants, aging is carried out simply by holding the quenched parts in boiling water for the desired time. Baths of circulating hot oil have been employed, these giving rapid heating and being susceptible of close temperature control. The treatment is also carried out in ovens or tanks heated by circulating steam or hot air, or in ovens (similar to core ovens) heated by fuel, electricity, steam coils, or oil coils. Aging with steam may not be economical unless steam is available and used for other purposes in the plant at all times. For batch aging of lots, the writer favors either electrically-heated ovens arranged for forced circulation of the atmosphere or ovens heated with circulating air introduced at regulated temperatures. For continuous aging, the electrically-heated low-temperature oven is satisfactory.

For the production quenching-and-aging treatment of such parts as pistons and brake shoes, special continuous equipment is used to advantage. In one installation, pistons are conveyed through the soaking furnace on a plate conveyor, discharged automatically into a quenching tank, removed therefrom on a conveyor, and then discharged automatically onto the plate conveyor of an aging oven. The cycle of operations requires from 3–6 hours, depending upon the size of the pistons, loading and the properties required. In both the solution and precipitation treatments of aluminum-alloy products, automatic control of temperature is a prime necessity.

## Defects in Heat-Treated Products

In the heat treatment of aluminum-alloy manufactures, the chief defects that may arise and cause rejection on inspection are cracks, incipient melting (so-called burnt parts), distortion and blisters. Of course, failure to meet specifications as to properties and, or, chemical composition is cause for rejection. In general, all defects are more numerous, the higher the quenching temperature.

Regarding cracks, this defect may be due to bumping or jolting the parts at the quenching temperature. All the aluminum alloys are more or less hot short, and are hence easily cracked or broken when hot. If castings are loaded

in baskets for heating previous to the quench, some of them may be cracked by movement of other castings or at least distorted. Some alloys are more "tender" (hot short) than others at the quenching temperature so that the scrap loss due to handling is normally higher when running certain compositions than others. Some slight cracks that would pass inspection in ordinary castings may open up into large cracks on heating and quenching. Hence, castings to be heat treated are usually given close inspection both before and after heat treatment. Close control of the soaking temperature is the only safeguard against incipient melting. As is apparent from the constitutional diagrams, the range of temperature available for maximum solution effect is often rather limited, especially in alloys containing more excess substance than can be taken into solid solution at any temperature. In lean alloys, there may be considerable spread between the solidus and the solid-solubility line (*EC* in Figs. 1 and 2). Burning is more likely to occur in alloys of the piston type for example, than in those of the magnesium-silicide type. In the former it is necessary to heat as close to the solidus line as possible in order to secure optimum hardening power; in the latter, it is necessary only to heat above the solid-solubility line. Burnt parts are usually recognized visually by dark color, collapse of wall sections or severe distortion.

Distortion, or warping, may be traced to several causes, including the composition of the alloy, temperature of heating, design of the parts and method of loading or handling. Complicated castings, and particularly those having thick and thin sections adjoining, are more prone to distortion on heating and quenching than castings having relatively uniform sections. Thin protuberant sections of castings are likely to bend, crack or go out of line on quenching. Parts in a load may be distorted by their own weight or the weight of superimposed parts. Mechanical equipment such as jigs, may be required to hold complicated castings in shape. In some parts, the stresses set up on quenching are released on subsequent machining, this causing distortion. The rapid cooling of quenching in liquid media is one primary cause of both cracks and distortion. Air quenching, being much less drastic than liquid quenching, is used for some parts in order to avoid defects. Quenching in boiling water sets up less internal stress than quenching in cold water. Light sections of sheet are prone to buckle on quenching, but any warpage may be removed by flattening or stretching. There is no distortion problem in the aging process. Blistering on heating is associated with dissolved gases, internal porosity and shrinkage cavities, as well as composition of the alloy. Hence, suitable precautions in melting, degassing and pouring practice are advisable in the production of parts to be heat treated.

Proper methods of inspection have been developed to recognize and cull out any defective parts after heat treatment and also such defects before heat treatment as might become more pronounced later. Suitable control technique has been developed to ensure that the heat-treatment processes have been properly carried out.

## Uses of Heat-Treated Manufactures

The development of heat-treatment processes has opened up new fields of usefulness for aluminum alloys and has made both cast and wrought products more adaptable and serviceable for standard applications. There have been many interesting developments in recent years which have made possible the use of heat-treated aluminum alloys in place of malleable iron and steel castings, brass and bronze castings, copper, brass and steel sheet, steel tubes and sections and steel forgings. Heat treatment has made possible the production of aluminum-alloy manufactures with so much higher mechanical properties that these materials are now being used for a wide variety of engineering purposes where it was formerly impractical to consider aluminum alloys at all. Such manufactures have now been on the market long enough and in service under such a variety of conditions as to thoroughly demonstrate their worth. While all the uses of heat-treated aluminum alloys cannot be listed here, it may be said in a general way that they have found the most usefulness and greatest variety of applications in all fields of modern transport—land, water and air. A further rapid increase in the use of heat-treated aluminum-alloy manufactures is seen in the modern tendency to save weight and increase speed in all kinds of transport.

Wrought and heat-treated aluminum alloys are produced in many commercial forms, including plate, sheet (both flat and coils), wire, shapes (both rolled and extruded), bars and rods, seamless tubing (in round, square and oval shapes), forgings, stampings, rivets and automatic screw-machine products. Sheet finds use in the construction of aircraft for wings, fuselage, gasoline tanks and other parts. The modern tendency in the construction of heavier-than-air ships is toward all-metal constructon. Duralumin is favored for this purpose. Large tri-motored ships for commercial and passenger purposes are built in this country by the Ford Motor Company, in which duralumin sheet is extensively used. In England, the Air Ministry has specified all-metal construction of aircraft. Fig. 13 shows a close-up view of a small ship of all-duralumin construction. In the construction of lighter-than-air ships (of the Zeppelin type)

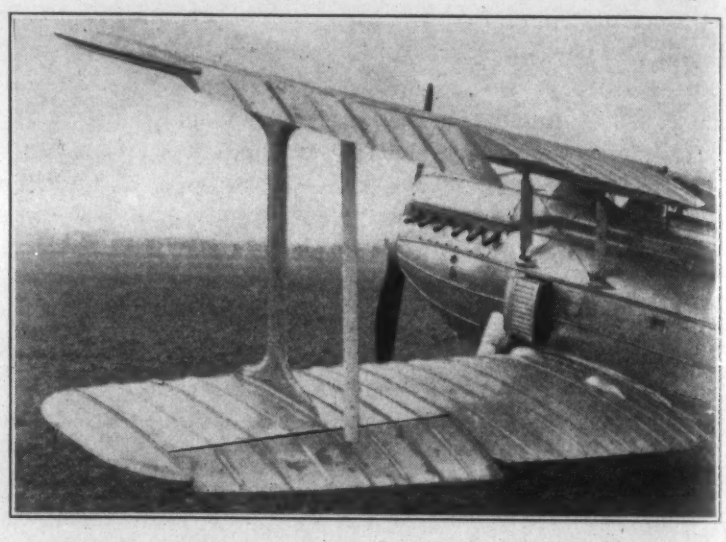

**Fig. 13—Airplane of All-Duralumin Construction (Carrol)**

duralumin sheet, shapes, tubes, sections and stampings are used for the rigid hull structure. While sheet of the heat-treatable alloys has hitherto found little application in motor-car construction, there has been a decided tendency lately toward the use of this material in building bus bodies and more recently for truck bodies. The forged aluminum-alloy propeller has generally supplanted steel and wooden propellers on aircraft. High-strength wrought alloys, including sheet, shapes and forgings, enter into the construction of light passenger cars on steam railways. Interesting developments have been made of late in the construction of street railway cars, in which aluminum-alloy products are used extensively. Reciprocating assemblies for locomotives, made largely of forged and heat-treated aluminum alloys, have been tried out with very satisfactory results. Aluminum-alloy forgings have been developed considerably of recent years for many parts in place of steel. The forged and heat-treated connecting rod is standard equipment on several passenger-car engines and is now coming in for truck and bus engines. Forged pistons are used in England in aviation engines, and forged crankcases find employment on some American radial aviation engines. Heat-treated aluminum-alloy cables are being used extensively in Europe in place of copper or aluminum cables for power transmission.

One of the most striking developments is the production of large I-beams and other shapes, hitherto available only

in steel, in heat-treated aluminum alloys. Such shapes are to find application in the construction of passenger cars for steam roads, and cars for street railways, elevated railways and subways. Structural shapes up to 90 feet long and 14 inches in section are now rolled commercially by the Aluminum Company of America at Massena, N. Y. Despite the considerably higher cost, it is possible that such shapes may also have application in the construction of towers on top floors of modern skyscrapers in place of steel. Such shapes are also expected to find application in the construction of large overhead travelling cranes, experimental types already built and run in competition with ordinary standard cranes being highly successful. Referring again to street-car construction, the all-aluminum car built for the Cleveland Railway Company in 1926 was so constructed that the weight per seated passenger was 550 pounds, as compared with 900 pounds for the regular type of car. Experience has shown that aluminum alloys can compete successfully with steel for car building. Duralumin rivets are used extensively in airplane construction. So-called Alclad sheet (duralumin covered with a thin coating of pure aluminum) finds use in aircraft construction for wings, pontoons, and for the envelope of metal-clad dirigibles.

The general field of application for both wrought and cast aluminum alloys is for stressed parts (and generally in place of heavier alloys), the only limitations being the possible mechanical properties and the cost. Among specific uses for heat-treated aluminum-alloy castings may be mentioned the following: Crankcases (for aircraft, motor car, motor coach, truck and fire engines), transmission cases, rear axle and differential housings, cylinder heads, pistons for gasoline and Diesel engines, bearing caps, brake shoes, wheels, outboard-motor parts, engine-suspension brackets and street-car parts. In aircraft, heat-treated castings are used for pump- and fuel-system parts, brackets, levers, wheels, cylinder blocks, crankcases, supercharger parts and a variety of smaller parts. Fig. 14 shows the 420 horsepower Pratt and Whitney Wasp radial aviation engine. This weighs 688 pounds. Heat-treated aluminum-alloy parts enter considerably into the construction of this engine. While so far, the chief applications of heat-treated castings have been in the transport field, interesting uses have also come in the moving parts of general machinery. There is an especially good future for the use of heat-treated castings in the construction of steam and electric railway cars.

One of the largest production items in heat-treated castings is the aluminum-alloy piston for motor-car engines. Prior to the introduction of heat treatment, the aluminum-alloy piston was used but little in the United States, although unheat treated pistons had been standard equipment abroad for years. American motor engineers favor high hardness in pistons. At the present time, the bulk of motorcar engines built in the United States are equipped with aluminum-alloy pistons. The Ford Motor Company consumes about 40,000 pistons per day when running at full production. Fig. 15 shows a machined aluminum-alloy piston of the strut type. To-day, practically any type of casting, irrespective of size, shape or weight can be heat treated, and the actual weight of parts treated has ranged from less than 1 ounce to over 1000 pounds. Heat-treatment plant is now a necessary adjunct in the modern light alloy foundry, and in the future the foundryman will be called upon more and more to produce castings in special alloys, heat treated and to rigid specifications. For stressed parts, un-heat treated products, both cast and wrought, have passed out of the picture.

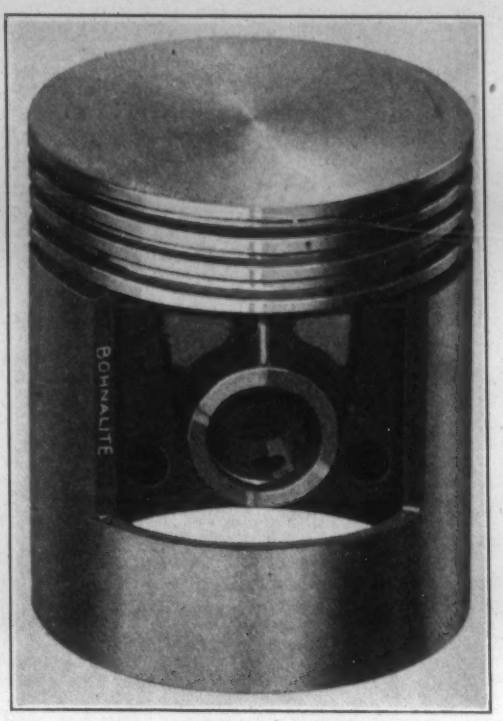


**Fig. 15—Aluminum-Alloy Piston for a Motor-Car Engine (Bohn Aluminum and Brass Corp.)**

While possible future developments are difficult to predict, the writer believes that the progress of the past will be much overshadowed in the next 10 years. The number of alloys for use in heat-treated manufactures will doubtless increase. It is quite unlikely that these alloys will be found accidentally, but rather will be developed by systematic research. Also, with more alloys available, it will be possible to select material especially suitable for particular purposes. If the price of aluminum should be reduced appreciably, there would be a large increase in the use of heat-treated aluminum-alloy manufactures, particularly in competition with steel.

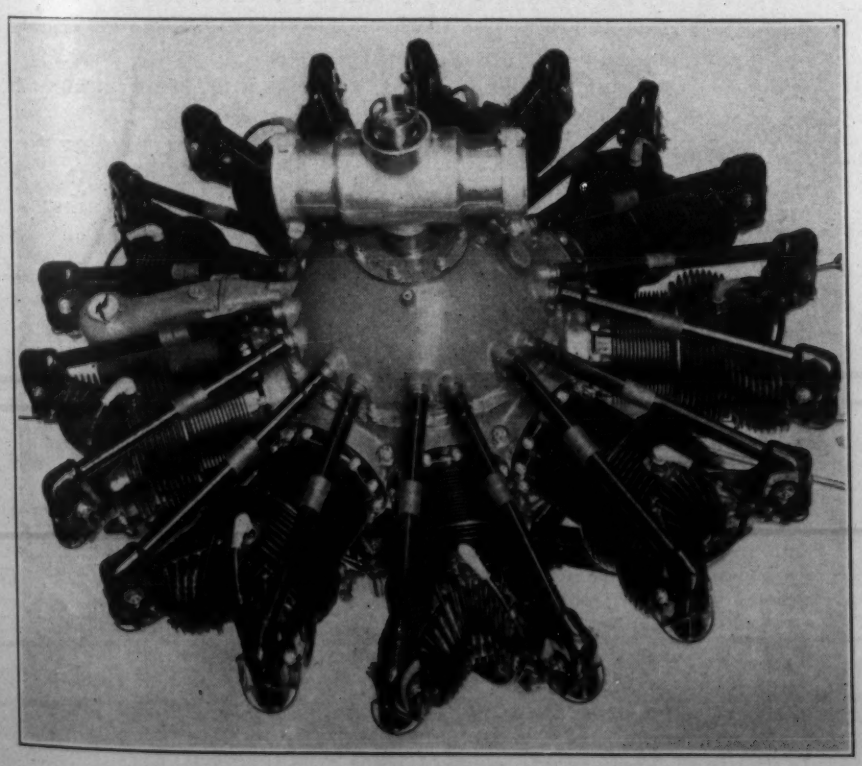

**Fig. 14—Wasp Aviation Engine; 420 Horsepower (Pratt and Whitney Aircraft Co.)**

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The number of published papers dealing with some phase of the heat treatment of aluminum alloys is so very large that the confines of space preclude any attempt at giving a comprehensive bibliography here. Following are some selected references to papers dealing with various aspects of the subject. Certain of these have bibliographies. From the references given here the whole literature may be readily tied in.

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## The Manganese Industry in 1929

In 1929, the first time since 1925, there was a substantial increase in the domestic production and shipments of manganese ore, containing 35% and more of manganese, due chiefly to increased output of sintered rhodochrosite in Montana, according to the United States Bureau of Mines, Department of Commerce.

The shipments of manganese ore (35% and more of manganese) from domestic mines were 60,379 long tons, valued at $1,612,357, in 1929, as compared with 46,860 tons, valued at $1,214,853, in 1928. In 1929, 47,597 tons was metallurgical ore and 12,782 tons, chemical ore, compared with 31,430 tons of metallurgical ore and 15,430 tons of chemical ore in 1928. Shipments of metallurgical ore in 1929 were 16,167 tons more than in 1928, whereas the shipments of chemical ore in 1929 were 2648 tons less than in 1928. For the fifth consecutive year there was a decline in the shipments of chemical ore, the shipments in 1929 being slightly more than half those of the peak shipments made in 1924.

Manganese ore was shipped from 11 States in 1929, of which Arizona, Arkansas, Georgia, Idaho, Montana, New Mexico and Virginia furnished 98% of the total shipments. Montana was the chief producing State in 1929, supplying 70% of the total. The other 4 states (California, Tennessee, Texas and Utah) yielded manganese ore in quantities ranging from a carload in Texas to 569 long tons in California.

## Personals

Dr. Lawrence W. Bass of Mellon Institute of Industrial Research spoke on "Industrial Research and Progress" at the September 11 Pittsburgh meeting of the Steel Founders' Society of America.

Gustavus J. Esselen announces the opening of new offices and laboratories at 73 Newbury Street, Boston Massachusetts. He and an experienced staff are continuing to give personal attention to problems of chemical research and technical development.

## Magnesium in 1929

The domestic output of new magnesium ingot increased from 521,075 lbs. in 1928 to 1,329,669 in 1929 or 155%, according to the United States Bureau of Mines, Department of Commerce. Magnesium has become a commercial material of substantial importance. Price reductions of 5–20 cents/lb. which became effective in January 1930, now place this metal on a competitive price basis with other light metals.

During the last two years the domestic output of primary magnesium has been all obtained from magnesium chloride recovered as one of the many co-products of the extensive industry based on the brine wells at Midland, Mich. The manufacture of ingot magnesium by the oxide process has been suspended.

Magnesium imported for consumption in 1929, according to the records of the Bureau of Foreign and Domestic Commerce, amounted to 3490 lbs., valued at $6539, and included alloys, powder, sheets and tubing.

## Metallurgical Advisory Board

The fourth annual open meeting of the Metallurgical Advisory Board will be held on Friday, October 17, 1930. The morning session will be devoted to a report and discussions on iron manganese carbon alloys and chrome nickel alloys. The physical chemistry of steel making will be reported on and discussed at the afternoon session.

All interested in the above problems, are invited to be present at these meetings. The executives and metallurgists of many of the large steel companies will attend the meetings and dinner.

Dr. Thomas S. Baker, President of the Carnegie Institute of Technology, will preside at the dinner at the Pittsburgh Athletic Association. Mr. Charles E. Wilson, Vice President of the General Motors Corporation, will be the principal speaker at the evening session. Mr. Wilson, who is a graduate of the Carnegie Institute of Technology, class of 1909, was formerly President of Remy Electric Division of the General Motors Corporation.

# Critical Abstract

*Dr. Gillett, the editorial staff and specially selected contributors will prepare abstracts of a critical nature on articles of special importance. The current literature will be covered in the Abstracts of Current Metallurgical Literature.*

## Lattice Distortion as a Factor in the Hardening of Metals[1]

The underlying causes for the hardening of metals have long been a source of speculation among metallurgists. To the keying action of small hard particles is acribed much of the hardness of duralumin, according to the theories of Merica and of Jeffries and Archer. The hardness of martensite is often ascribed to lattice distortion. Various other causes are ascribed, but for the moment, lattice distortion is receiving much attention, especially in Europe. One of the outspoken adherents of the lattice distortion explanation is Rosenhain of the British National Physical Laboratory.

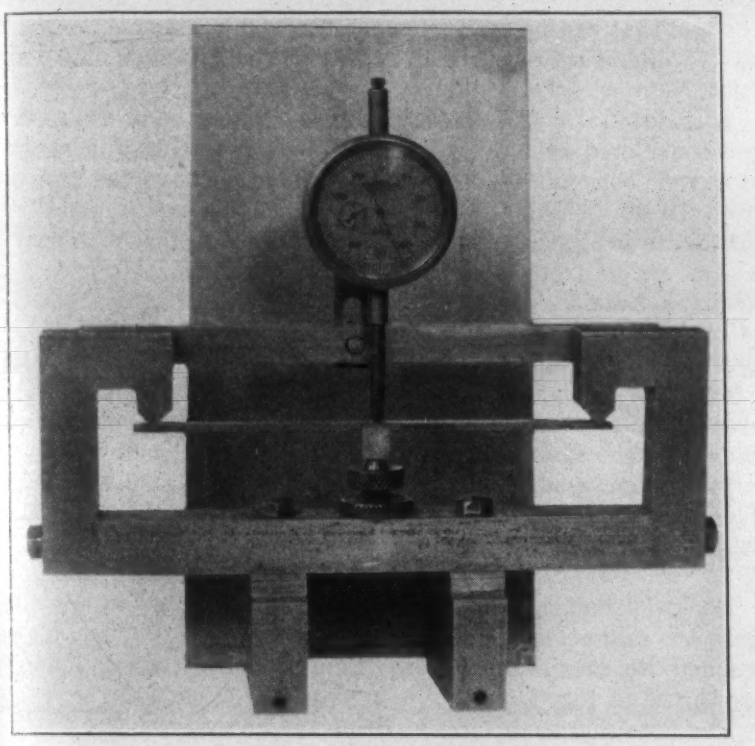

Fig. 1

At the suggestion of Dr. Jeffries, Fink and Van Horn have carried out some experiments aimed to clarify the understanding of the problem, and, bearding the lion of foreign opinion on the subject in his den, have described them before the British Institute of Metals.

Lattice distortion produces a widening of the X-ray diffraction lines. When an adherent of the lattice distortion theory finds that the diffraction lines occur when a metal is hardened, he says, "Aha! lattice distortion, hardening, post hoc, propter hoc."

Now the lattice is distorted and the bands widened when a metal is elastically deformed. Hence, if a bar is bent elastically and the X-ray diffraction lines from the bent surface are measured, one should find the widening of the bands due to lattice distortion. Fink and Van Horn rigged up a simple apparatus (Fig. 1) and observed the widening of the bands for heat-treated duralumin and a 70:30 $\alpha$-brass. The widening was perceptible and should, if lattice distortion is the sole factor in producing hardness, be accompanied by a perceptible increase in hardness.

But when the bent specimen, clamped so as to have exactly the same tensile stress in the outer fibers as when it was subject to the X-ray diffraction study, was subjected to a Rockwell hardness test, instead of being found harder, it was *softer*. A duralumin specimen of 93.5 Rockwell E hardness in the unstressed condition, dropped to 88.6 when stressed at 14,600 lbs./in.$^2$ and one of brass, originally 64.7 dropped to 58.0 at 14,550 lbs./in$^2$. This is shown in Table I and the curve for duralumin is shown in Fig. 2.

[1] W. L. Fink and K. R. Van Horn, (Aluminum Company of America) *Preprint* 534 for October 1930 Meeting, *British Institute of Metals*, 7 pages.

**Table I—The Effects of Stress on Duralumin ("17S") and Alpha Brass Specimens**

| | Duralumin "17S" | | 70:30 Alpha Brass | |
|---|---|---|---|---|
| | Specimen 1 | Specimen 2 | Specimen 5 | Specimen 6 |
| Tensile stress. lbs./in.$^2$ in the outer fibers | 14,600 | 15,000 | 14,550 | 14,840 |
| Decrease in hardness during stress, % | 5.2 | 5.5 | 10.3 | 7.3 |
| X-Ray Examination | | | | |
| X-ray exposures before or during stress, hrs. | 24 | 24 | 64 | 68 |
| Increase in Diffraction Line Width During Elastic Stress* | | | | |
| | Mm. | Mm. | Mm. | Mm. |
| 111 | 0.1 | < 0.1 | < 0.1 | < 0.1 |
| 002 | 0.2 | 0.2 | 0.2 | 0.2 |
| 022 | 0.2 | 0.2 | 0.3 | 0.2 |
| 113 | 0.3 | 0.2 | 0.4 | 0.5 |
| 222 | −0.1 | ... | ... | ... |
| 004 | < 0.1 | < 0.1 | ... | ... |
| 313 | 0.2 | 0.3 | ... | ... |
| 024 | 0.2 | 0.4 | ... | ... |

* The width of the lines in the diffraction patterns was obtained by the simple expedient of enlarging the pattern (×3) and measuring the resulting print with a 0.5-mm. scale. The values were recorded in hundredths of a millimeter, as shown in Table II. The line width differences so obtained were rounded off to the nearest tenth of a millimeter, as indicated in Table I.

While this does not prove that lattice distortion of a very local character might not harden a metal, but it does at least indicate, as Fink and Van Horn state, that "considerable caution should be exercised in attributing the hardening of metals to lattice distortion."

**Table II—Line Width Measurements of Two Duralumin ("17S") Specimens**

(No External Load Applied)

| Planes | 111 | 002 | 022 | 113 | 222 | 004* | 313 | 024 |
|---|---|---|---|---|---|---|---|---|
| | Mm. | Mm. | Mm. | Mm. | Mm. | Mm. | Mm. | Mm. |
| Specimen 3† | 0.67 | 0.72 | 1.09 | 1.67 | 1.83 | 1.93 | 2.13 | 2.13 |
| Specimen 4† | 0.64 | 0.76 | 1.05 | 1.45 | ... | 1.68 | 1.93 | 1.93 |
| Difference in width | 0.03 | −0.04 | 0.04 | 0.22 | ... | 0.25 | 0.20 | 0.20 |

* Reflections of very low intensity.
† Specimens from same hard-rolled sheet and heat-treated together.

An interesting side observation (see Table II) was that two specimens of hard rolled duralumin, cut from the same sheet and heat-treated together both had exactly the same hardness value, but the width of the X-ray bands showed differences between the two specimens in respect to the width of some of the diffraction bands that were nearly as great as those produced by a stress of 14,600 lbs./in$^2$. That is, quenching stresses almost up to the elastic limit of the material did not affect the hardness at all.

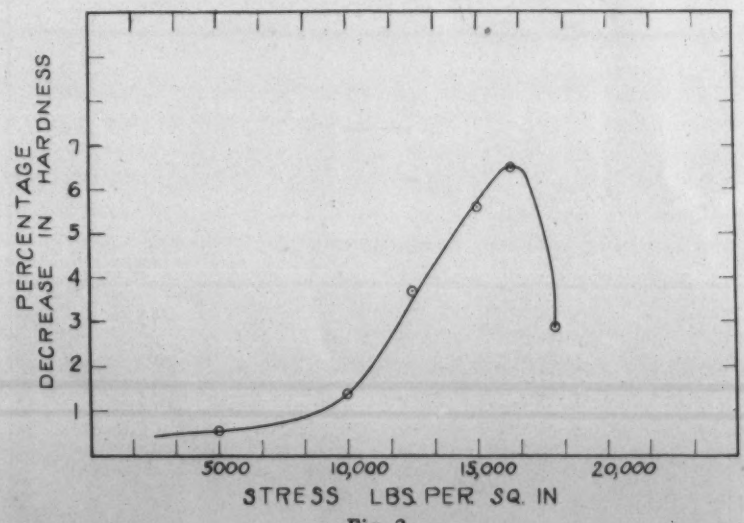


Fig. 2

Different lots of heat-treated duralumin, of the same static properties, may differ quite a bit in their endurance properties. X-ray studies so far have thrown no light on these differences, but in view of this observation it appears to the abstractor that precise measurement of the width of the diffraction bands might possibly throw some light on the problem. It is very probable that the presence or absence of quenching stresses would have much bearing on the endurance properties.—H. W. Gillett.

# Extended Abstract

*Selected articles that appear to be of outstanding importance or interest will be abstracted in this section at greater length than Abstracts of Current Metallurgical Literature. The important points will be given fully enough to obviate for the purposes of most readers, the necessity of going to the original article, but in a distinctly condensed form. These Abstracts are not critical.*

## Relationship between Rockwell and Brinell Numbers[1]

By S. N. Petrenko

Manufacturers are more and more adopting methods of control which help to insure the safe and satisfactory performance of their product. Brinell and Rockwell indentation tests are two rather widely used means of checking for uniform quality in metallic products. Situations are constantly arising in which accurate data for converting Brinell indentation numbers into corresponding Rockwell numbers, or vice versa, are of great practical value.

Data on the conversion of Brinell-Rockwell hardness numbers previously obtained on a variety of ferrous and non-ferrous products, and published by the Bureau of Standards,[2] have been extended by the study of some 200 additional steels of many compositions (including common and unusual alloy steels) in various conditions of heat treatment. The tensile strength had been determined on over 100 of these. Detailed data on composition, heat-treatment and properties are given in the original paper.

Direct hardness comparisons run up to 750 Brinell. The range of tensile strength covered by the steel specimens run from about 50,000–283,000 lbs./in.$^2$

Theoretical conversion formulae were calculated on certain geometrical assumptions, and the actual values compared with these.

Due to flattening of the ball or deformation of the indenting tool due to compression and to elastic recovery of the material tested, experimental results vary from those that would be obtained with a rigid ball and under the other conditions imposed in the theoretical computations. The form of the theoretical curves gives an idea of that of the actual curves, but the useful curves are those experimentally determined.

[1] *Bureau of Standards Journal of Research*, July 1930, Vol. 5, pages 19–50.
[2] Relationship Between Rockwell and Brinell Numbers, S. N. Petrenko. *Technologic Papers of the Bureau of Standards*, No. 334, 1927, Vol. 21, pages 195–222. (Superseded by the present paper.)

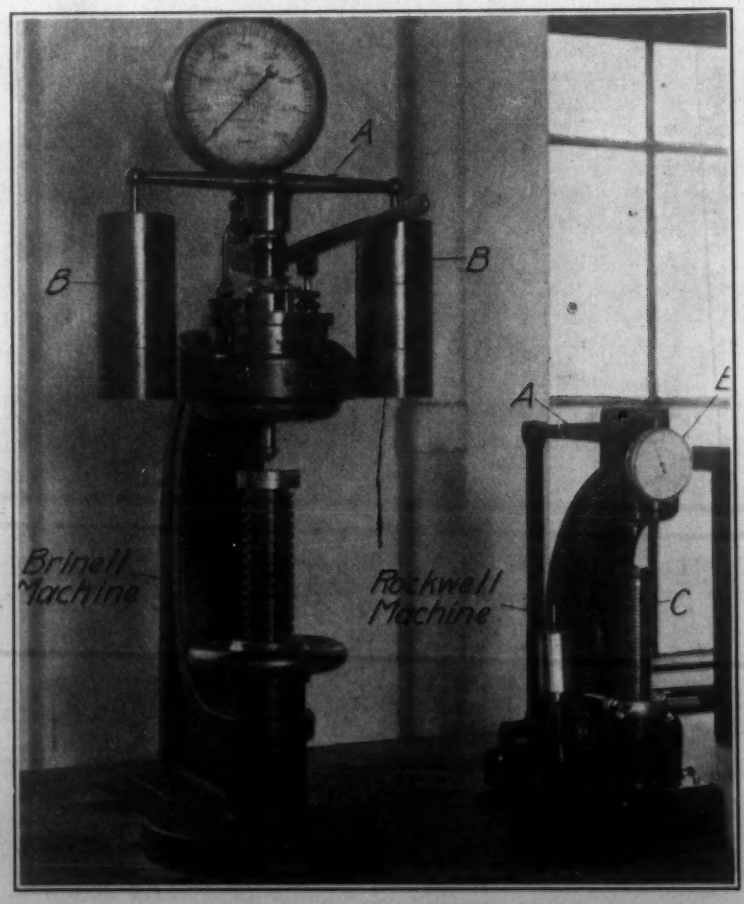


**Fig. 1—Brinell and Rockwell Machines**

The value of an experimental curve depends on the number of observations it represents. The large number of observations in this work makes the curves very representative.

Empirical formulae representing these curves are given in the figures. Since scatter of the data about these curves amounts to ± 10%, it is obvious that the converted hardness number obtained by calculation is not necessarily any closer to the truth than the one that can be read from the conversion plots. Sometimes two formulae are required to represent the two ends of the same curve.

It is stated that the tensile strength-hardness conversion curves are considered reliable within ± 15%, save that the range of Rockwell cone numbers that may thus be converted run only from 10–40 (90,000–190,000 lbs./ in.$^2$), the experimental data for the curve above C 40 not being considered sufficient to warrant a conversion from higher Rockwell numbers. However, the available data fit the plotted curve with less scatter from C 40 –C 53 than those from C 33–C 40.

The Brinell tests were made with a 10 mm. Hultgren work-hardened steel ball, with a load of 3,000 kg. for Brinells of 70 or above, and of 50 kg. for those below 70, the load applied 30 seconds and the indentation measured with a Brinell microscope with 0.1 mm. graduations, readings being estimated to 0.01 mm. The corresponding Brinell numbers were taken from the usual table (Bureau of Standards Miscellaneous Publication No. 62).

Rockwell ball and cone numbers were obtained in the usual way, the major load being left on approximately $^3/_4$ sec. after it reached its maximum value. The hardness testing machines are shown in Fig. 1.

The notation used is $B_n$ = Brinell Number.

100 $R_B$ $^1/_{16}$ = Rockwell Ball Number $^1/_{16}$" diam. ball 100 kg. load
100 $R_B$ $^1/_8$ = Rockwell Ball Number $^1/_8$" diam. ball 100 kg. load
150 RC = Rockwell Diamond Cone (brale) 150 kg. load
60 RC = Rockwell Diamond Cone (brale) 60 kg. load

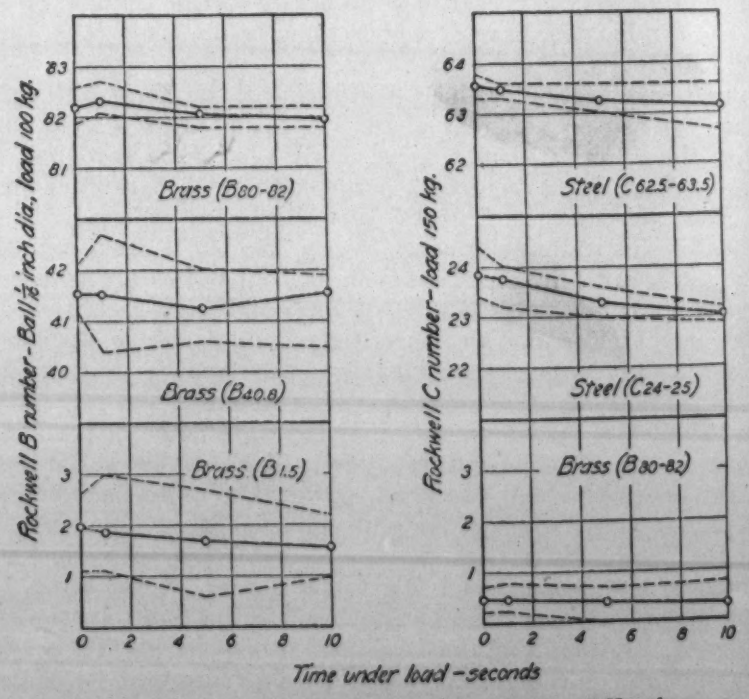


**Fig. 2—Effect of Time under Load upon Rockwell Number**

Circles represent average values obtained from 5 indentations. Dash lines show extreme variations. Values for zero time were obtained within $^1/_2$ second of the instant the major load reached its maximum value. Identification marks on the standard blocks are given in parentheses.

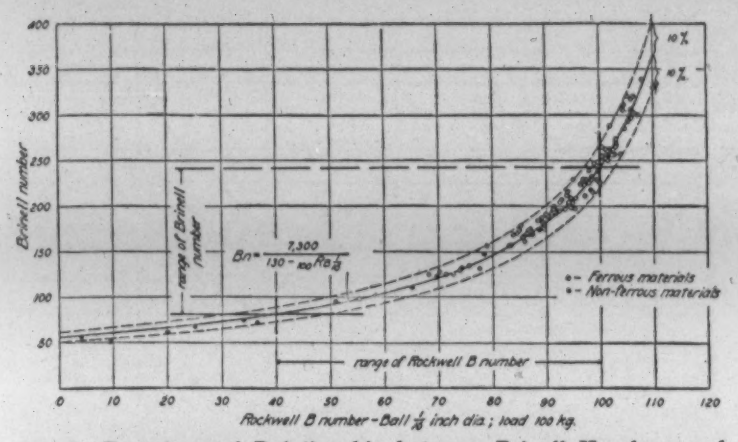
Brinell number
range of Brinell number
Bn = 7,300 / 130 − 100 Ra 1/16
range of Rockwell B number
o – Ferrous materials
• – Non-ferrous materials
+10%
−10%
Rockwell B number – Ball 1/16 inch dia.; load 100 kg.

**Fig. 3—Experimental Relationship between Brinell Numbers and Rockwell Ball Numbers, Ball Diameter 1/16 Inch**

The ranges indicated are those over which the empirical conversion curve may be applied with the expectation of no error greater than 10%.

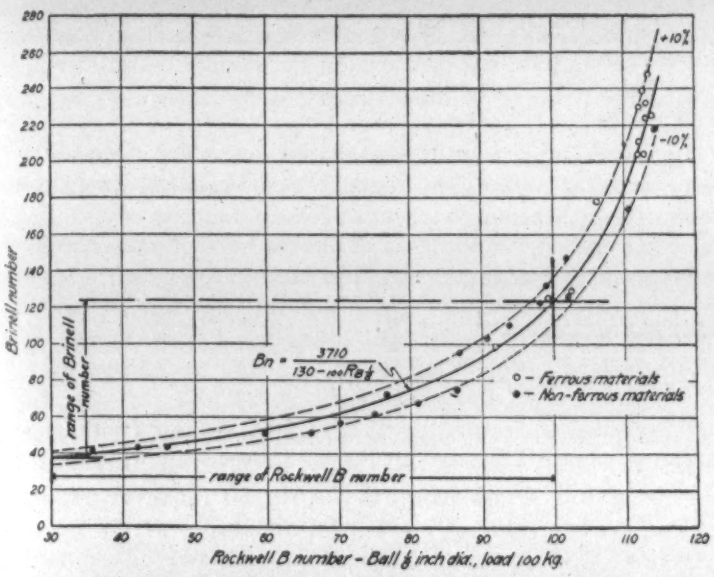
Brinell number
range of Brinell number
Bn = 3710 / 130 − 100 Ra 1/8
range of Rockwell B number
o – Ferrous materials
• – Non-ferrous materials
+10%
−10%
Rockwell B number – Ball 1/8 inch dia., load 100 kg.

Fig. 4—Experimental Relationship between Brinell Numbers and Rockwell Ball Numbers, Ball Diameter 1/8 Inch

The ranges indicated are those over which the empirical conversion curve may be applied with the expectation of no error greater than 10%.

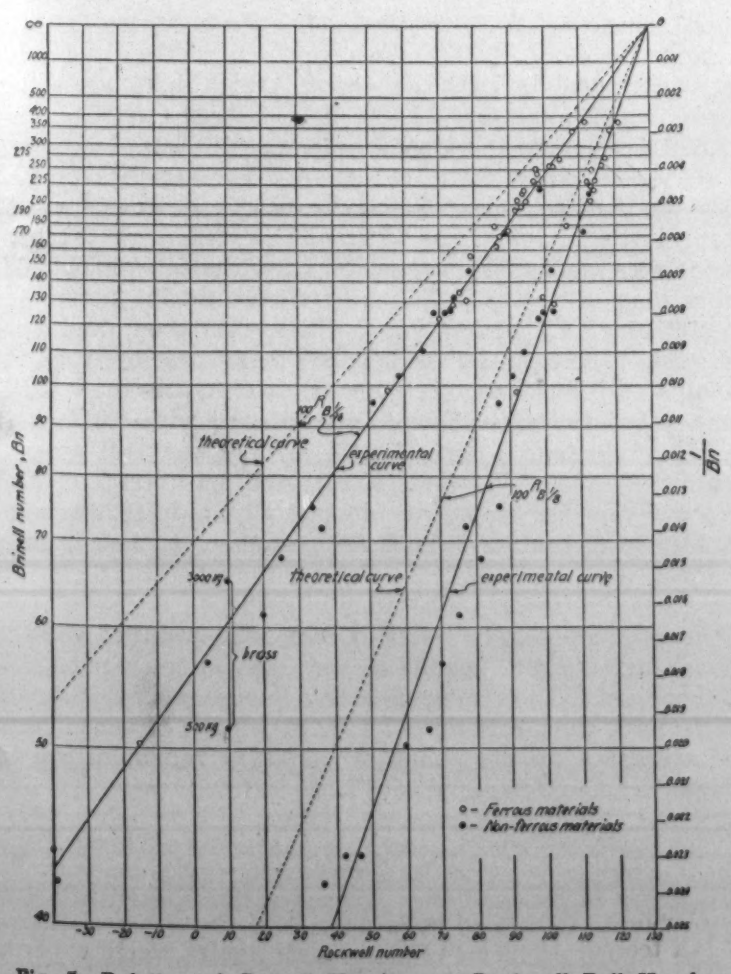


**Fig. 5—Relation of Brinell Numbers to Rockwell Ball Numbers**

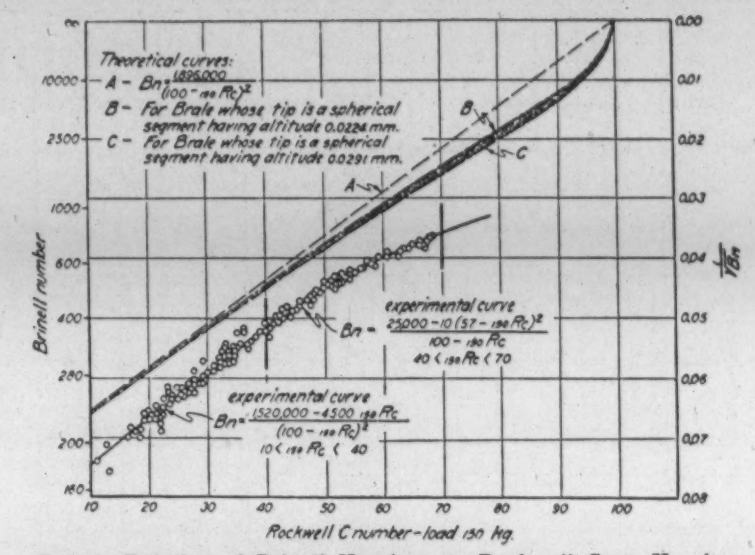
Theoretical curves:
A – Bn = 1825000 / (100 − 100 Rc)²
B – For Brale whose tip is a spherical segment having altitude 0.0224 mm.
C – For Brale whose tip is a spherical segment having altitude 0.0291 mm.
experimental curve
Bn = 2500 − 10 (57 − 100 Rc)² / 100 − 100 Rc
40 < 100 Rc < 70
experimental curve
Bn = 1520000 − 4500 100 Rc / (100 − 100 Rc)²
10 < 100 Rc < 40
Brinell number
Rockwell C number – load 150 kg.

**Fig. 6—Relation of Brinell Numbers to Rockwell Cone Numbers**

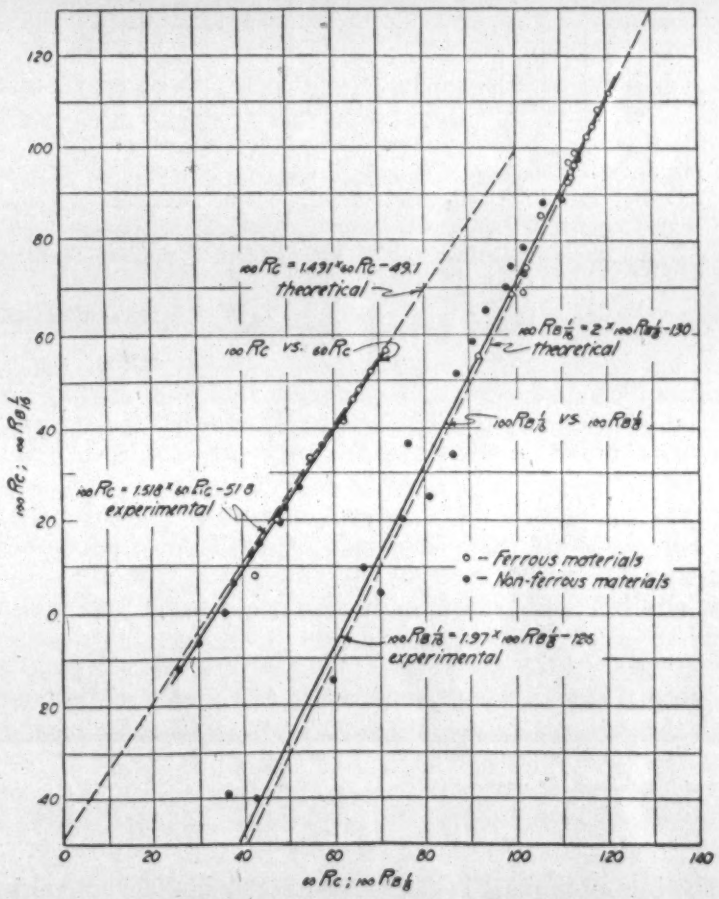
100 Rc = 1.491 * 60 Rc − 49.1
theoretical
100 Rc vs. 60 Rc
100 Ra 1/16 = 2 * 100 Ra 1/8 − 130
theoretical
100 Ra 1/8 vs. 100 Ra 1/16
100 Rc = 1.518 * 60 Rc − 51.8
experimental
o – Ferrous materials
• – Non-ferrous materials
100 Ra 1/16 = 1.97 * 100 Ra 1/8 − 128
experimental
60 Rc ; 100 Ra 1/8

**Fig. 7—Comparison of Rockwell Numbers**

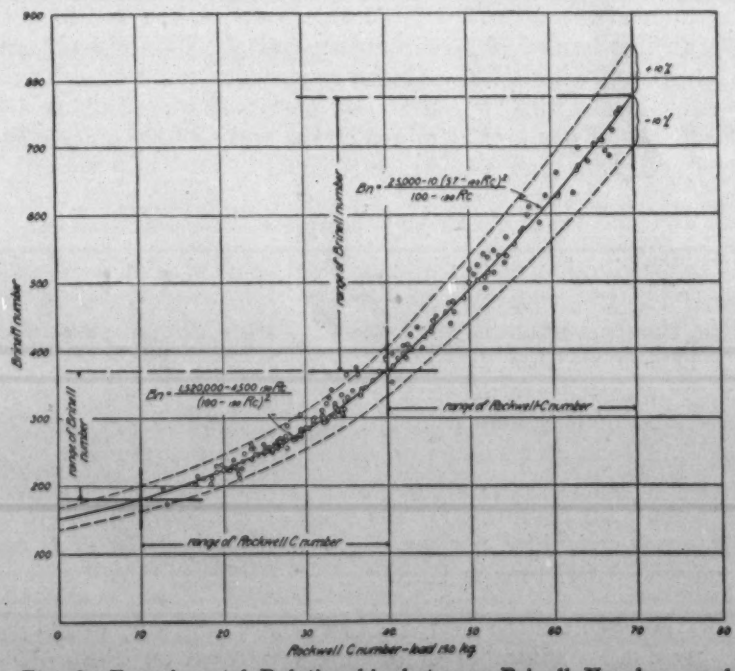
Brinell number
range of Brinell number
Bn = 25000 − 10 (57 − 100 Rc)² / 100 − 100 Rc
Bn = 1520000 − 4500 100 Rc / (100 − 100 Rc)²
range of Brinell number
range of Rockwell C number
range of Rockwell C number
+10%
−10%
Rockwell C number – load 150 kg.

**Fig. 8—Experimental Relationship between Brinell Numbers and Rockwell Cone Numbers**

The ranges indicated are those over which the empirical conversion curves may be applied with the expectation of no error greater than 10%.

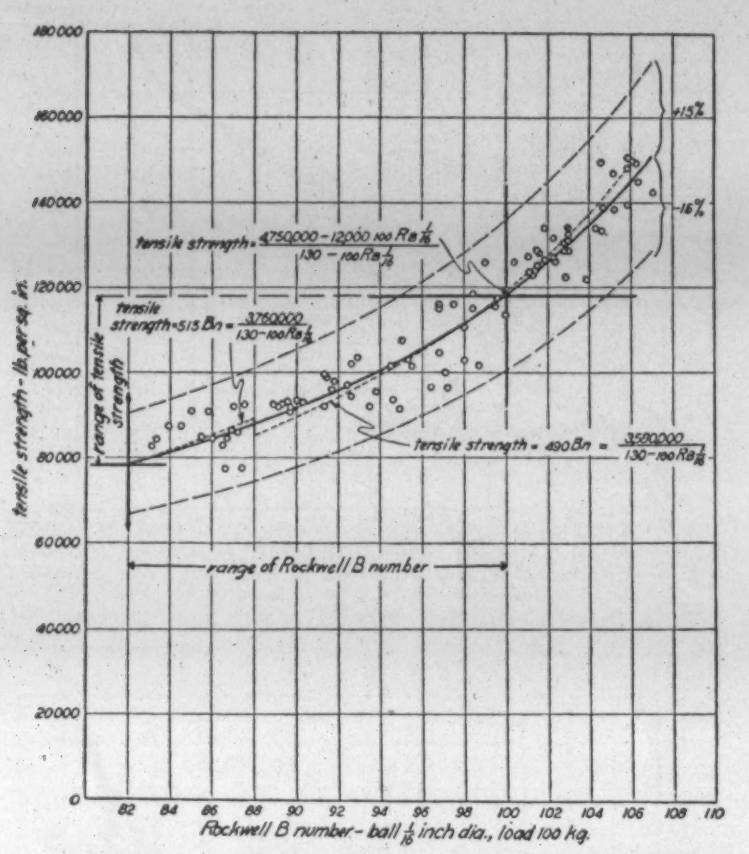
tensile strength - lb. per sq. in.
Rockwell B number - ball 1/16 inch dia., load 100 kg.
range of Rockwell B number
range of tensile strength
+15%
-15%

**Fig. 9—Experimental Relationship between the Tensile Strength of Steel and Rockwell Ball Number. Ball Diameter 1/16 Inch**

The ranges indicated are those over which the empirical conversion curve may be applied with the expectation of no error greater than 15%.

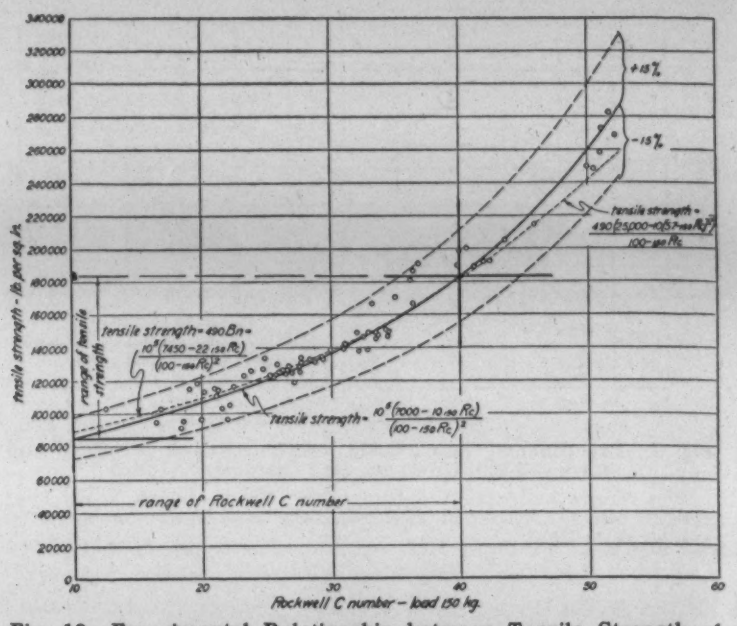


**Fig. 10—Experimental Relationship between Tensile Strength of Steel and Rockwell Cone Number**

The ranges indicated are those over which the empirical conversion curve may be applied with the expectation of no error greater than 15%.

The captions for the curves and the curves themselves give the information contained in the article essential for use in conversion or estimation of strength from hardness.

Comparisons with conversion curves given by other observers are given in the original.—H. W. GILLETT.

# The Iron Industry in 1929

The year 1929 in the iron and steel industry was one of large production and increased earnings, according to the United States Bureau of Mines, Department of Commerce. The production of steel ingots in 1929 reached a new peak, exceeding the previous record year 1928 by about 8.5%. The increased needs of the steel industry were naturally reflected in the outputs of pig iron and ferro-alloys, the production of pig iron reaching a peak total of 41,761,488 gross tons, a gain of 5% over the previous record made in 1923, and ferro-alloys, reaching 869,563 gross tons, the second largest output on record. Although not keeping pace with the outputs of steel and pig iron, the production of iron ore was the third largest on record, for the third time in history the output exceeding seventy-three million tons.

## Iron Ore

The iron ore mined in the United States in 1929 amounted to 73,027,720 gross tons, an increase of 17% as compared with 1928. Compared with the average for the preceding five years the production in 1929 is greater by 19%. The shipments of iron ore in 1929 amounted to 75,602,734 gross tons, valued at $197,148,640, an increase of 19% in quantity and of 27%, in total value, as compared with 1928. The average value per ton of iron ore at the mines in 1929 was $2.61, as compared with $2.46 in 1928. The stocks of iron ore at mines at the end of 1929 amounted to 7,067,206 gross tons, a decrease of 23%.

## Pig Iron

The production of pig iron in 1929, exclusive of ferro-alloys, was 41,761,488 gross tons, compared with 37,410,897 tons in 1928. Thus, the production in 1929 was 12% more than in 1928, and it was 17% more than the average for the preceding five years. In the production of pig iron in 1929 there were used 72,330,926 gross tons of domestic iron ore and manganiferous iron ore; 2,887,814 tons of foreign iron ore and manganiferous iron ore; and 6,817,314 tons of cinder, scale and scrap; a total of 82,036,054 tons. An average of 1.964 gross tons of metalliferous materials was consumed per ton of pig iron made in 1929, as compared with 1.937 tons in 1928.

The shipments of pig iron from blast furnaces in 1929, amounting to 41,549,161 gross tons, valued at $731,858,075, showed an increase of 8% in quantity and of 11% in total value. The general average value of pig iron of all grades at the furnaces in 1929 was $17.61 a ton, as compared with $17.27 in 1928.

## Ferro-alloys

The shipments of ferro-alloys of all classes in 1929 amounted to 829,324 gross tons, valued at $75,506,078, an increased of 4% in quantity and of 13% in total value. The production of ferro-alloys in 1929 was 869,563 gross tons, as compared with 757,131 tons in 1928, an increase of 15%.

The production of ferromanganese in 1929 was 339,205 gross tons, containing about 269,000 tons of manganese (metal), an average of about 79.3% of manganese. In the production of ferromanganese in 1929 there were used 614,762 gross tons of foreign manganese ore, 46,385 tons of foreign ferruginous ore, 27,558 tons of domestic manganese ore, 1350 tons of iron ore, and 7,811 tons of cinder, scale and scrap. The quantity of manganese ore used per ton of ferromanganese made in 1929 was 1.894 tons; in 1928 it was 1.891 tons; and in 1927 it was 2 tons. Of the foreign manganese ore used in 1929, Russia supplied 267,600 gross tons; Brazil, 228,737 tons; India, 86,547 tons; Africa, 28,592 tons; Cuba, 2050 tons; Chile, 1187 tons; and Turkey, 50 tons. The quantity of domestic manganese ore used in the manufacture of ferromanganese in 1929 represented 4.3% of the total manganese ore used, as compared with 6.3% in 1928.

The production of ferrotungsten in 1929 was 3101 gross tons, containing 5,389,937 tounds of tungsten, an average of 77.59% of tungsten. The shipments of ferrotungsten in 1929 amounting to 3049 tons, contained 5,302,435 pounds of tungsten, and the average value per pound of contained tungsten was $1.10 f. o. b. furnaces, compared with 93 cents in 1928.

The production of ferrovanadium in 1929 was 1823 gross tons, containing 1,540,912 pounds of vanadium, an average of 37.74% of vanadium. The shipments of ferrovanadium in 1929, amounting to 1,767 tons, contained 1,494,291 pounds of vanadium, and the average value per pound of contained vanadium was $3.12 f. o. b. furnaces, compared with $3.20 in 1928.

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The representatives of the Calorizing Company, Pittsburgh, Pa., received a shipment of their new bulletin on Calite Alloys at the Metal Congress in Chicago by air mail. This bulletin is now available for distribution. It contains charts and tables, which show the physical properties of various Calite alloys, as well as illustrations of applications.

The Battelle Memorial Institute has issued a 32-page booklet, which describes the facilities for research service made available to industry at the Institute. Copies of this booklet will be sent on request to interested individuals, companies, associations and groups having problems of a technical nature which apparently may be solved by research.

# Translation

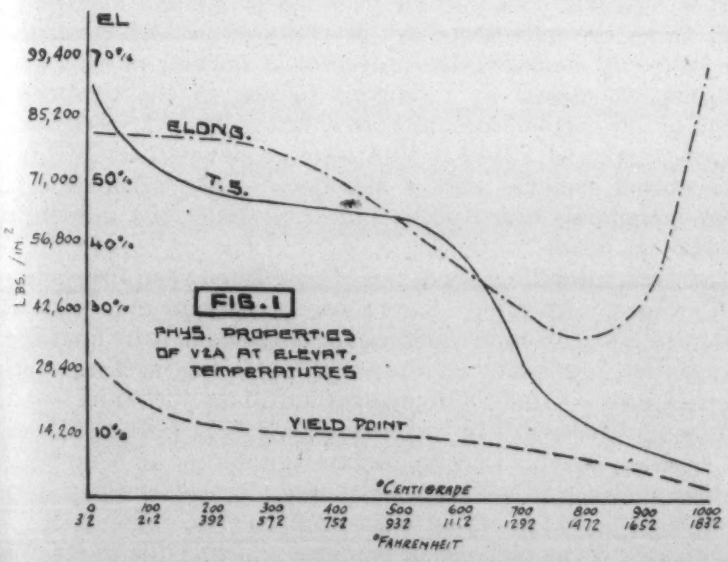
*The readers of* METALS & ALLOYS *will be assured of receiving in this section an extended abstract in English of the best articles appearing in foreign publications.*

# Carbide Precipitation during Drawing of Corrosion Resistant Non-Magnetic Chromium Nickel Steel*

By B. Strauss, H. Schottky and J. Hinnüber

The present publication deals with Krupp's V2A the analysis of which is C under 0.16%, Ni 8.5% and Cr 18.0%. The approved heat treatment for this steel has been heating to temperatures above 1100° C. (2012° F.) followed by rapid quenching in water without subsequent drawing. The original quenching temperature used exclusively for a long time was 1150–1200° C. (2102–2192°F.). The reasons for this treatment are as follows: In the first place, the recrystallization range of this steel is considerably higher than that of iron and also of other austenitic steels[1] and so heating above 1000° C. (1832° F.) is necessary in order to overcome the strain hardening due to working at temperatures below this range. In the second place, the solubility of carbon in the γ-solid solution below 1000° C. (1832° F.) is very low, the carbon separating from the solid solution in the form of carbide particles of an unknown composition. The carbide dissolves more and more at the higher temperatures and it is desirable to obtain and preserve this condition of homogeneous solid solution characterized by maximum softness and ductility by quenching from a high temperature.

**The Influence of Carbide Precipitation on Physical Properties.**—It has been found in practice that there is a hot working range for the V2A steel in which it is particularly liable to cracking. In this range the tensile tests at elevated temperatures show a minimum elongation which is the more pronounced, the higher the C-content of the steel. (See Fig. 1.) This fact proves that the decrease in toughness is caused by the precipitation of carbide particles. Besides this the tensile strength decreases uniformly in this temperature range and does not show a break or pass through a maximum as would be expected if a change took place in the matrix.




The physical property changes of V2A steel after drawing are shown in the following tables. The data in Tables I and II refer to a steel with 0.13 C, 9.0 Ni and 18.1 Cr. For Table III a steel of 0.12 C, 8.32 Ni and 17.8 Cr was used. The tensile and impact test pieces were taken from forged round bars which had been quenched in water from 1150° C. (2102° F.) and then given the drawing treatment indicated.

**Table I**

| Tempering Time in Hrs. | Tensile Strength in Lbs./in.² after Tempering at: 500° C. (932° F.) | 600° C. (1112° F.) | 700° C. (1292° F.) | 800° C. (1472° F.) |
|---|---|---|---|---|
| 0 | 92,400 | 92,400 | 92,400 | 92,400 |
| 1 | 89,500 | 92,700 | 93,500 | 90,800 |
| 50 | 88,300 | 94,200 | 97,500 | 98,100 |
| 300 | 88,300 | 94,700 | 103,700 | 98,500 |

**Table II**

| Tempering Time in Hrs. | Elongation in % (l = 5 × d) after Tempering at: 500° C. (932° F.) | 600° C. (1112° F.) | 700° C. (1292° F.) | 800° C. (1472° F.) |
|---|---|---|---|---|
| 0 | 60 | 60 | 60 | 60 |
| 1 | 67.5 | 62 | 61 | 62 |
| 50 | 69.5 | 60 | 57 | 49.5 |
| 300 | 68.5 | 56.5 | 47.5 | 50.5 |

**Table III**

| Tempering Time in Hrs. | Impact Hardness in mkg./cm.² after Tempering at: 500° C. (932° F.) | 600° C. (1112° F.) | 700° C. (1292° F.) | 800° C. (1472° F.) |
|---|---|---|---|---|
| 0 | 24.2 | 24.2 | 24.2 | 24.2 |
| 1 | 22.7 | 22.0 | 22.7 | 21.7 |
| 10 | 23.8 | 21.8 | 20.4 | 18.3 |
| 50 | 24.6 | 20.9 | 19.2 | 11.7 |
| 300 | 22.1 | 20.8 | 12.3 | 3.7 |

According to these tables, the largest changes in physical properties occur after drawing to 700° C. (1292° F.) and 800° C. (1472° F.). The changes are relatively small in the tensile tests, the tensile strength and elongation changing in inverse order. In the impact test the changes show up only after a very long drawing time.

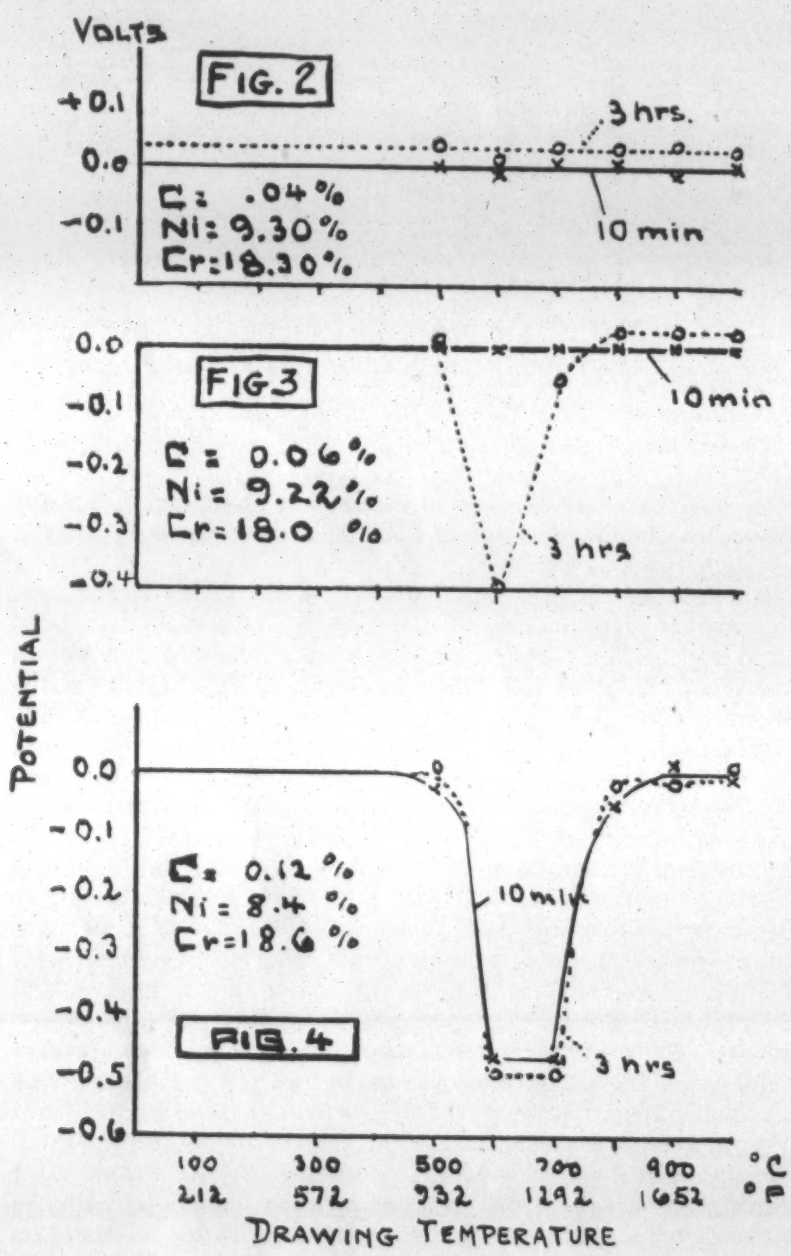
**Influence of Carbide Precipitation on Corrosion Resistance. Potential Measurements.**—Brittleness in V2A steel has been found repeatedly. The metal loses its soundness and sheets occasionally become as pliable as moist cardboard before disintegrating completely into a crystalline powder. This disintegration is due rather to a loss of strength than to brittleness. The observation that these changes frequently occur under the influence of chemicals led to the inference that intercrystalline corrosion, which has also been noticed by other investigators in various metals and alloys, was the underlying cause.[2] In some cases the deterioration took place under the influence of atmospheric corrosion or was due to traces of acid found in the atmosphere around chemical plants or adhering to the steel after pickling. The disintegration always starts at the surface and never on the inside, thus proving the nature of a corrosion process. Since brittleness was only found in service in exceptional cases, the assumption was made that the trouble was due to a faulty heat treatment. The exact proof could be furnished by potential measurements. In a paper previously published[3] it is stated that an alloy of the composition of V2A steel after drawing at 700° C. (1292° F.) shows a periodic fluctuation in electrochemical potential due to the precipitation of carbides at the grain boundaries, the fluctuations indicating first a tendency of the metal to go into solid solution then a tendency to become passive. On the other hand the same alloy in a condition of homogeneous solid solution shows a constant noble potential. The surface, because of the precipitation of carbides at the grain boundaries, has areas of base potential which tend to form local elements.

In the investigation which was made, the solution was evacuated down to a pressure produced by a suction pump and a protective atmosphere of hydrogen applied. In this way it became possible to measure potentials either noble or base depending only on the heat treatment of the test pieces. A Binant electrometer was used as a measuring device and a tenth normal calomel electrode as a reference electrode. To eliminate the influence of the surface of the test piece, all samples were uniformly ground then pickled to remove the cold worked layer. After being pickled the samples were carefully cleaned to get rid of adherent solution products. It is furthermore important to consider the length of time elapsed during the storage after pickling, since the hydrogen absorbed from the acid opposes the formation of the passive layer. The test pieces were stored for about half a day in a dessicator with an open tube.

The data shown in Figs. 2 to 4 refer to V2A steel with various C-content and practically constant Cr and Ni content. The drawing times were 10 min. and 3 hrs. respectively. A water

* Original appeared in *Zeitschrift für anorganische und allgemeine Chemie*, Vol. 188, March 1930, pages 309–324.

quench was used to preserve the various structures. The curves show that no distinct change in passivity took place in any of the three alloys. At higher drawing temperatures the dominating influence of carbon on passivity shows up. The 0.04 C samples proved to be insensitive to drawing. It is true that the 0.06 C samples remain unaltered after a short drawing time (10 min.) but the sample drawn at 600° C. (1112° F.) has a base potential after long drawing (3 hrs.). The 0.12 C V2A samples drawn at 600° C. (1112° F.) and at 700° C. (1292° F.) show a potential less noble than that of hydrogen (−0.34 volt) after only 10 min. By increasing the drawing time from 10 min. to 3 hrs. the potential of the 0.12 C steel does not change appreciably.




An examination of the surface of the samples in some cases indicates that the corrosion resistance decreases with increasing drawing times.

**Artificial Development of Intercrystalline Corrosion.**—Measurement of potential difference gives important information in regard to relationships among analysis, but it includes several inconveniences. The method requires special skill and the results are affected by accidental changes in the outer surface layer. Furthermore, difficulties are encountered if the sample has not been uniformly heat treated and lastly the measurement of potential does not give any information as to how rapidly the disintegration of the sample will take place. It was, therefore, felt highly desirable to produce the disintegration artificially and as quickly as possible.

The necessary condition for the beginning of intercrystalline corrosion seems to be a hydrogen-ion concentration. To reduce the corrosion effect of the solution an inhibitor should be added. There are numerous solutions employed for development of intercrystalline corrosion as moist air containing $CO_2$, acetic, oxalic, citric and sulphurous acids, very diluted solutions of phosphoric, fluorosilicic, hydro-sulphuric and nitric acid and others. However, it was found that a hot dilute solution of $H_2SO_4$ with additions of $CuSO_4$ was a particularly convenient and effective reagent. Due to the base potential at the grain boundaries caused by the precipitation of carbides, copper is deposited and the grain boundary substance dissolved, whereas the interior of the grains remains unattacked due to its noble potential.

A further means of identifying intercrystalline corrosion in addition to the characteristic loss of soundness and strength is the micro-examination of a smoothly polished surface. The areas of attacked grain boundaries stand out against the areas of sound structure without etching due to the diffusion of the reflected light.

This method in accordance with potential measurement proved that 600–700° C. (1112–1292° F.) is the critical tempering range which causes the beginning of intercrystalline corrosion.

**The Process of Carbide Precipitation.**—It is not the amount but rather the type–particularly the degree of dispersion–of the precipitation which decides the loss in potential and the intercrystalline corrosion. An initial precipitation finely dispersed results in an appreciable destruction of the grain boundaries due to the correspondingly large number of local elements whereas at higher temperatures a coagulation into fewer but larger particles takes place. At temperatures below 600° C. (1112° F.) the precipitation of carbides has not yet begun. At 600° C. the precipitated particles are so fine as to be recognized under the microscope only by the experienced eye. Their carbon coming from the immediate vicinity is reinforced only at higher temperatures by an immigration from the interior of the grains.

The rates of cooling as well as the drawing times which a steel can stand can be determined by the test for intergranular corrosion. It was found, for example, that a 0.14 C V2A alloy cooled from 1150 to 400° C. (2102 to 752° F.) in four minutes showed a tendency toward intercrystalline corrosion, which was not the case after the cooling time was cut down to 36 seconds.

Little is known in the literature of the nature and behavior of carbides in austenitic steels, to which fact attention has been called by Greulich and Bedeschi[3] in a recently published paper. These authors studied the precipitation and re-solution of carbides in drawing an austenitic steel. Although working with a material of different composition and in the cold worked state, a count of the carbide particles and the plotting of these values as a function of the drawing temperature shows a behavior quite similar to that found in V2A steel. The particle number in the solution range above 800° C. (1472° F.) is an exponential function of the temperature, according to these authors.

It is also true that carbide particles of a size which may be seen under the microscope are precipitated in V2A steel within the grains by annealing after severe cold working or after severe deformation caused by rolling or forging in the temperature range of low carbide solubility, say, below 900° C. (1652° F.).

Lester[4] studied a 0.10 C V2A steel at elevated temperatures. This author believes that a migration of the carbides to the grain boundaries takes place, but only under the influence of mechanical force.

**The Structural Changes in the Matrix Due to the Precipitation of Carbides. Magnetic Saturation Measurements.**—Unstable austenite, i. e., austenite which can be obtained only by quenching, changes to martensite on drawing, increasing with increasing temperatures or time of tempering until the austenite is completely transformed. In some steels, e. g., 12% Mn steel, it has not yet been possible to carry this transformation to completion.[5] Certain austenitic Cr-Ni-steels undergo a transformation during the cooling period after heating to 850–900° C. (1562–1652° F.) as indicated by an increase of hardness which is due to a carbide precipitation. No martensite can be noted in the microstructure. Nevertheless, a very accurate test method, the measurement of magnetic saturation[6] offers very distinct indications of the occurrence of $\alpha$-iron accompanying the precipitation of carbides. The increase of saturation is the greater the higher the C content, i. e., the greater the carbide precipitation. Due to the formation of Cr-carbide particles the matrix around the carbide particles becomes lower in Cr, which causes a decrease in stability during tempering, which in turn causes the formation of martensite.

The tempering temperature at which maximum magnetic saturation takes place does not coincide with the drawing temperature for maximum carbide precipitation, but occurs at 700° C. (1292° F.) at which temperature $\alpha$-iron disappears due to the transformation into $\gamma$-iron. Since the electrochemical potential and the tendency toward intercrystalline corrosion

also show curves quite similar to the magnetic saturation in relation to drawing temperature it is highly significant that it is not the occurrence of carbides but the presence of $\alpha$-iron that accounts for this phenomenon. However, this interpretation is not indisputable either. If the Ni-content in V2A is increased to 12% a decrease in potential and a tendency toward crystalline corrosion is found on drawing but no increase in saturation. This contradiction can be eliminated by the assumption that not the formation of $\alpha$-iron but the impoverishment of the matrix in Cr is responsible for the loss in potential. In spite of this impoverishment, the matrix will remain austenitic if a high Ni-content is present and consequently no increase of magnetic saturation will occur. A corroboration of this interpretation is afforded by a steel of 0.15 C, 20 Ni, 25 Cr (heat resistant alloy) which has only a slight tendency toward intercrystalline corrosion. The Cr-content is obviously high enough to prevent the development of a base matrix due to the loss of Cr in the vicinity of the carbide particles.

A further supplementary assumption seems to be required, namely, that above 700° C. (1292° F.) equilibrium by means of diffusion takes place in a relatively short time due to the greater mobility in the space lattice so that no local impoverishment in the alloy content of the matrix occurs in spite of the increasing carbide precipitation.

[1] Schottky and Jungbluth. *Krupp'sche Monatshefte*, Vol. 4 (1923), page 197.
[2] Rawdon. *Industrial and Engineering Chemistry*, Vol. 19 (1928), pages 613–619.
[3] *Archiv für das Eisenhüttenwesen*, Vol. 3 (1929), page 359.
[4] *Transactions American Society for Steel Treating*, Vol. 16 (1929), page 106.
[5] Hadfield and Hopkinson. *Journal Iron & Steel Institute*, Vol. 89 (1914), page 106.
[6] Stäblein and Schröter. *Zeitschrift für anorganische und allgemeine Chemie*, Vol. 174 (1928), page 195.

## Frank L. Driver, Sr.

The Driver-Harris Company, Harrison, N. J., has announced with keen regret the death of Mr. Frank L. Driver, Sr., Chairman of the Board of Directors and one of the founders of that Company. Mr. Driver died in Belgium on August 26th, 1930, where he had been residing for the past five years due to ill health.

The alloy industry loses one of its oldest representatives through the death of Mr. Driver, who founded the Driver-Harris Company in 1899 and was associated with it until his death. He was always keenly alive to improvement and expansion and it was largely due to his foresight and pioneering that the industry has grown to its present proportion.

Mr. Driver was born in Brooklyn on July 4th, 1870. He was the President of the Company he founded until 1925 when he retired to the Chairmanship of the Board of Directors.

## Member of Editorial Advisory Board Awarded Howe Medal

METALS & ALLOYS wishes to announce the award of the Howe Medal to Mr. H. J. French, a member of its Editorial Advisory Board. He is a metallurgist for the International Nickel Co.

## Calendar of Meetings

**American Gas Association,** Atlantic City, N. J., Oct. 13–17.
**British Cast Iron Research Association,** London, England, Oct. 29.
**American Petroleum Institute,** Chicago, Ill., Nov. 10–13, 1930.
**American Chemical Society,** Intersectional Meeting, Buffalo, N. Y., Nov. 28, 29.
**American Institute of Chemical Engineers,** New Orleans, La., Dec. 8–10, 1930.
**Association for the Advancement of Science,** Cleveland, Ohio, Dec 29–Jan. 31, 1931.
**National Western Metal Congress and Exposition,** San Francisco, Cal., week of Feb. 16, 1931.

## Appointment of Research Associate American Electroplaters' Society

At a meeting of the Research Committee in Washington on June 30th, it was decided that the present funds warrant the appointment of a Research Associate for a period of one year, with a reasonable certainty that sufficient additional funds will be collected during the coming year to continue his services. The specific subject to be studied by him at the Bureau of Standards is the protective value of plated coatings, especially of chromium.

For this position the Committee feels that the following qualifications are desirable:

1—Graduation from a course in chemistry or chemical engineering in a college of recognized standing.
2—A few years experience, preferably in research or development work in electrochemistry or electrodeposition.
3—Ability to present the results of research clearly and forcibly to those interested.

The salary to be paid will depend upon the qualifications of the person selected, and is likely to be between $2400 and $3600 per year, with a reasonable rate of promotion.

Any person who desires to be considered for this position is requested to send an application to Dr. William Blum, Bureau of Standards, Washington, D. C. This should include his name, age, address, education and experience, the minimum salary he will accept and the names of former teachers or employers who are familiar with his qualifications. All applications will then be considered by the Research Committee.

## Steel Wing Beams in Production

The manufacture of steel wing beams on a production basis is going forward at the plant of Metallurgical Laboratories, Inc., (Metlab), Phila., Pa., of which Horace C. Knerrr, Consulting Metallurgical Engineer, is President. Orders are in hand for fifteen sets of spars for the Curtiss Kingbird, a twin motored 8 place transport monoplane being manufactured at the Curtiss Robertson plant, St. Louis. Several sets of spars have already been completed and production is proceeding rapidly. This work is under the direct charge of Mr. Harold A. Backus.

The design of the spar is exceptionally efficient, having been developed and carried through the experimental stages under Mr. T. P. Wright, Chief Engineer of the Curtiss-Wright Company at Garden City. The beams are of the Warren truss type and the material is Summerill chrome-molybdenum steel tubing (4130X). The flange members are of elliptical section. The lattices are rounds, joined to the flanges by acetylene welding, the tension members passing completely through the flanges and being welded on both sides. The parts are assembled by Metlab in the annealed condition, accurate steel jigs and fixtures being employed. After assembly the beams are heat treated to a tensile strength of 140,000–150,000 lbs./in.$^2$ in specially designed vertical electric furnaces being quenched in oil from 1600° F. and tempered to the desired ductility.

Distortion during heat treatment, which has hitherto prevented the successful production of steel wing beams assembled by welding, has been entirely avoided in the Metlab heat treating process. This has permitted the economical and efficient use of steel in the construction of aircraft spars. These beams are said to be as light and strong as the best designs in wood and aluminum alloys, at the same time having advantages of cost, ruggedness, permanence, reduced crash and fire hazard, etc. The weight of the beams is 43 pounds and the overall length 21$^1/_2$ feet.

The heat treatment of steel to a strength of 150,000 lbs./in.$^2$ makes it as light as duralumin as a material of construction. Assembly by welding permits the most efficient use of material and avoids the excess weight and local sacrifice of strength inherent to the use of rivets or fittings. The type of construction embodying welded and heat treated alloy steel, therefore, appears to have the maximum possibilities for weight saving, together with other obvious advantages. This fact is being recognized by leading aircraft manufacturers, a number of whom have already adopted the method or are carrying forward experimental designs.

Six unusual overhead traveling cranes have recently been built by the Northern Engineering Works of Detroit for the U. S. Aluminum Company of Pittsburgh, Pa., to be used in their new sheet rolling mills at Alcoa, Tennessee. The unusual feature of these cranes is that each entire unit is made from aluminum alloy rolled structural sections and aluminum alloy castings.

The crane bridge is a latticed type girder construction—the first of this type ever designed and built for crane purposes. The bridge structure is made of rolled aluminum structural sections, #17ST alloy. The trucks which carry the bridge are aluminum castings made of #195 alloy. It is interesting to note that all rivets, the "T" rail on which the crane trolley runs, nuts, hooks, angles, fittings, etc., are of aluminum. The total net weight of the entire crane, including the trolley, is 30,000 pounds.

### Correspondence Welding Course Announced

Stuart Plumley, Minneapolis, Minn. announces a 20-lesson course for welders.

# Abstracts of Current Metallurgical Literature

*These abstracts are not critical, but merely review developments as they are recorded. The various classifications are numbered. This number is at the end of each abstract and will be of assistance in mounting them on cards for filing.*

## EFFECTS OF ELEMENTS ON METALS & ALLOYS (27)

**Vanadium and Titanium in Cast Iron.** J. E. Hurst. *Foundry Trade Journal*, Vol. 41, Sept. 5, 1929, pages 173–174; *The Foundry*, Vol. 57, Dec. 15, 1929, page 1067.

Previous investigations studying the influence of small additions of V and Ti to cast iron are reviewed and valuable possibilities are discussed in the commercial development of cast iron containing V and Ti. Vanadium increased the tensile, transverse and compressive strengths of cast iron according to several investigators. Donaldson reports that 0.15% in ordinary work increases the tensile strength by 7740 lbs./in.$^2$ and a cast iron that had failed in a transverse test with a load of 1300 lbs., attained a load of 2200 lbs. with the addition of 0.135% vanadium. This material exercises a strong effect on the grain of cast iron causing a more even distribution of the graphite and gives freedom from porosity. In chilled castings vanadium tends to produce a deeper and stronger chill less likely to spall and flake. Vanadium iron takes on a high finish on machining and tooling, and has been used successfully in making glass bottle molds, blanks and plunger.—*Vancoram Review.* (27)

**Investigation of the Effects of Impurities on Copper. Part VI. The Effect of Phosphorus on Copper.** D. Hanson, S. L. Archbutt & Grace W. Ford. *Journal Institute of Metals, Advance Copy* 522 (1930), 22 pages; *Engineering*, Vol. 129, April 18, 1930, page 522; *Engineer*, Vol. 149, Mar. 28, 1930, pages 345–346.

The authors have systematically investigated the properties of copper containing up to approximately 1.50% of phosphorus, other impurities being kept to the smallest practicable amount. A summary of previous work is given. The present investigation was made with metal from billets containing from 0.014–0.95% phosphorus which were prepared and rolled and deals with macro- and micro-structure, hot- and cold-rolling behavior, density, hardness, tensile tests at ordinary and elevated temperatures, electrical conductivity, fatigue properties, impact strength, softening temperature of cold worked material, determination of the solubility of phosphorus in solid copper and age-hardening tests. Most of the tests were made with rolled products. The presence of phosphorus improves the casting properties and removes oxygen from copper. With 0.04% and more, of phosphorus, the densities of cast ingots resemble those of the corresponding rolled rod. In the presence of 0.05% phosphorus and above ingots tend to be less sound. Very low phosphorous content also produces unsound ingots. The hardness of cast ingots increases with increasing phosphorus. The removal of oxygen with phosphorus results in better cold-working properties. Cast billets containing 0.95–1.20% phosphorus can be hot-rolled, and billets containing up to 0.79–0.95% phosphorus can be cold-rolled. The addition of phosphorus was found to raise the softening temperature of cold worked material, and to improve all the mechanical properties that were covered by the investigation. Phosphorus is seriously detrimental to electrical conductivity, which fact is attributed to its solubility in copper. Slight age-hardening was found, the maximum effect occurring with 0.95% phosphorus. Munker's results are given but a direct comparison with the earlier work is not possible owing to differences in experimental conditions. The endurance limits, by rotating beam test on annealed rod, were raised by increase in phosphorus. Starting at 11,000 lbs./in.$^2$ at about 0.01% phosphorus, the endurance limit rose to 12,000 at 0.03% phosphorus, to 15,000 at 0.15% phosphorus, fell to about 13,500 at 0.18–0.25% phosphorus, then rose to 15,000 again at 0.50% phosphorus and to 16,500 at 0.80% phosphorus. The dip in the curve is, however, ascribed to blow-holes in the 0.18– and 0.25% phosphorus specimens. From the context, in which reference is made to "the two specimens" that gave abnormally low fatigue results, it would appear possible that only one specimen was used for a fatigue test, starting at a low stress and raising the stress till the specimen broke, in which case the results might be vitiated by the strengthening effect of understressing. Save for the sample with lowest phosphorus, the tensile strength curve for the annealed samples shows steadily increasing strength with increase in phosphorus. AEH&LM(27)

**The Influence of Various Alloying Elements on the Transformation Points of Carbon Steel. (Der Einfluss verschiedener Legierungselemente auf die Kritischen Punkte von Kohlenstoffstahl.)** A. Merz. *Archiv für Eisenhüttenwesen*, Vol. 3, May 1930, pages 587–596; *Stahl und Eisen*, Vol. 50, April 17, 1930, pages 518–519; *Iron & Coal Trades Review*, Vol. 120, Apr. 4, 1930, page 571.

Chevenard's dilatometer is critically considered, certain improvements are described which permit obtaining curves with clear transformation points. These improvements necessitate a new design of the head of the dilatometer. The importance of a most uniform heating velocity is proved by the investigations. The methods formerly used for a uniform heating are altered by introducing a new resistance working in an absolutely automatic manner. The accuracy of the new apparatus was tested in determining the transformation points of electrolytic iron and carbon steels. The observation of a gradually increasing dilatation within the transformation range is attributed, according to Honda's explanation, to an orientation of the lattice units. Contradictory to Kasé's thermal investigations (*Science Reports Tohoku University*, Vol. 14 (1925), pages 173–217) it was found in investigating the dilatometric behavior of nickel steel with and without carbon content that carbon has an decreasing influence on the transformation points of nickel steels. The results of H. Esser (*Stahl und Eisen*, Vol. 47 (1927), pages 2021–2031) in examining binary chromium-iron alloys are confirmed. A decrease of the transformation points in adding carbon was found which is in accordance with the thermal investigations by Maurer and Hohage (*Mitteilungen Kaiser Wilhelm Institüt für Eisenforschung*, Vol. 2 (1921), pages 91–105). A noticeable relation between carbon content and the transformation points of Cr-C alloys does not exist. Nickel lowers the transformation points of chromium steels, especially Ar is lowered. The opposite influence of chromium does not appear. The values of tungsten steels are in good accordance with those obtained by W. Zieler (*Archiv für Eisenhüttenwesen*, Vol. 3, July 1929, pages 61–78). The results of investigation of binary iron-silicon alloys confirm Esser's dilatometric results (H. Esser, Report No. 69, of the Material Committee of the Verein deutscher Eisenhüttenleute). Carbon widens the closed $\alpha$-field. Iron manganese alloys without carbon content give the same results as Dejean found (*Comptes rendus*, Vol. 171 (1920), pages 791–794). Manganese added to carbon steels result in a smaller decrease of the transformation points. The author finally describes a method to combine a Saladin apparatus with a dilatometer in order to clear up the discrepancies between the results obtained by thermal and dilatometric investigations. RHP&GN(27)

**Nickel Cast Iron.** P. D. Merica. *Transactions American Society for Steel Treating*, Vol. 16, Aug. 1929, pages 314–325.

The effects of nickel are discussed in detail, and some notes are given on machinability and strength of alloy iron, on the step bar test and on the relation of nickel and silicon in cast iron. It also deals with the individual improvements effected by the presence of nickel as illustrated by typical examples from current foundry practice: automobile cylinder blocks, piston rings, ammonia compressor heads, printing press rolls, locomotive cylinders, etc. The article closes with a brief summary of procedure in the foundry production of cast iron. (27)

**A Note on Zinc Base Die-Casting Alloys.** R. Lancaster & J. G. Berry. *Journal Institute of Metals, Advance Copy* 524 (1930), 2 pages; *Engineering*, Vol. 129, Mar. 28, 1930, page 429.

The effect of small additions of magnesium to zinc-base alloys hardened with copper and aluminum has been examined. The authors note a change in crystal structure and a variation in physical properties with additions of magnesium from 0.1–0.5%. AEH&LM(27)

**Distribution of Carbon in Steels.** B. M. Larsen. *Iron & Coal Trades Review*, Vol. 120, Feb. 21, 1930, page 335.

Abstract of U. S. Bureau of Mines, Technical Paper 466 on the "Effect of Manganese on Distribution of Carbon in Steel." Three factors determine the modifying effects of manganese on carbides in the iron–carbon system. These are: (1) manganese tends to enlarge the temperature-range of stability of gamma iron or austenite; (2) manganese forms a carbide more stable than cementite; (3) manganese atoms can hardly diffuse at all through the iron space-lattice at ordinary heat-treating temperatures at which carbon atoms diffuse quite freely. RHP(27)

**Influence of Nickel on Combined Carbon in Cast Iron.** J. R. Houston. *Transactions American Society Steel Treating*, Vol. 15, Jan. 1929, pages 145–157.

Tests with a step casting showed that nickel additions lessened the difference in combined carbon between thick and thin sections and between "cast hot" and "cast cold" test pieces. (27)

**Nickel Casting Alloys.** J. McNeil. *Metal Industry* (London), Vol. 36, Mar. 7, 1930, pages 275–278; Mar. 14, 1930, pages 305–306.

Includes discussion. Paper read before the Co-ordinating Committee at Birmingham. Deals chiefly with non-ferrous alloys, referring briefly to the use of Ni in steel castings. Nickel brasses consist of $\alpha$-solid solution structure, and those having an $\alpha + \beta$ or $\beta$ structure. Former includes the nickel silvers. Nickel silvers contain about 60% Cu and the rest Zn and Ni. Gives table with chemical composition and trade names of the nickel silvers. Sound nickel silver castings are readily obtainable, having good surface finishes. The melting points vary between 900 and 1200° C. according to composition. Correct casting temperature is of considerable importance. Lists the various uses. In $\beta$ brasses Ni is added to obtain increased mechanical properties. Cites results of other investigators. Other alloys discussed are complex nickel brasses, nickel bronzes, high nickel content bronzes nickel-copper alloys, nickel-chromium, nickel-chromium-iron alloys, miscellaneous nickel non-ferrous alloys and nickel steel castings. VSP(27)

**The Influence of Aluminum Lead, Iron and Tin in Brass. (Der Einfluss von Aluminium, Blei, Eisen und Zinn im Messing.)** *Zeitschrift für Metallkunde*, Vol. 21, May 1929, pages 152–159.

The paper summarizes the work of a special committee of the Deutsche Gesellschaft für Metallkunde which investigated the influence of contaminating metals in brass mainly Al, Pb, Fe and Sn. The investigations begun in 1920 and supervised by Prof. W. Guertler, were carried out in 5 leading German brass producing plants and cover 11 series of alloys. The influence of these mtals on commercially important properties was the goal of this comprehensive research work, i. e., elastic limit, tensile strength, elongation, reduction of area, Brinell Hardness, bending capacity, torsion, deep drawing and drilling properties. The testing material was studied in the form of brass sheets, wires and bars. It was established that additions of lead amounting to 4% in 57, 60 and 65 (% Cu) brass do not influence yield point and tensile strength whereas reduction of area, bending and torsion strength are reduced notably. Machineability is favorably influenced by Pb. Erratic results were experienced in the Fe-containing (2%) 60 and 62 brass sets. Generally spoken, strength is increased and elongation is reduced. A detrimental effect of the low contents of Fe in commercial brands is denied. The results in the Al-Zn-Cu alloys also fluctuate. If Zn is replaced by Al an increase of strength, a decrease in elongation, reduction of area and deep drawing values were observed. The experiments refer to 68 and 62 brass in which Zn was replaced by Al up to 4%. A decidedly favorable influence of Sn on tensile properties was established in 82 brass. An addition of 5% Sn for instance raises the yield point about 100%. EF(27)

**Tensile Properties of Cast Steel at Higher Temperatures with Special Regard to the Influence of Nickel. (Festigkeiteigenschaften von Stahlguss bei höhren Temperaturen unter besonderer Berücksichtigung des Einflusses von Nickel.)** E. Piwowarsky & H. Nipper. *Giesserei*, Vol. 17, April 1930, pages 329–333.

The influence of Ni on the physical properties of annealed and unannealed cast steel is studied at 20–500° C. (hardness up to 800°), using specimens containing 0%, 1.54% and 3.00% Ni. With increasing Ni up to 1.5% all of the physical properties are improved, while with further increase the hardness, tensile strength and rolling limit are raised, and the notch toughness and elongation are decreased. The tensile strength and notch toughness of the annealed specimens is greater than that of the unannealed, while the effect of annealing on the hardness and elongation is irregular. (27)

**New Investigations Upon the Influence of Iron, Silicon and Manganese on the Aging of Duralumin. (Neue Untersuchungen über den Einfluss von Eisen, Silizium und Mangan auf die Duraluminveredlung.)** K. L. Meissner, *Zeitschrift für Metallkunde*, Vol. 21, Oct. 1929, pages 328–332.

The paper, presented before the Deutsche Gesellschaft für Metallkunde, points out that iron, silicon and manganese are not indispensable for the age-hardening of duralumin at room temperature.. The age-hardening of Al-Cu alloys can be accomplished solely by Mg while Si is absent. The theory generally accepted regarding the influence of $Mg_2Si$ upon the age-hardening of duralumin is not maintained. Additions of Fe, which appreciably effects the binary Al-Cu alloys, is without influence upon the age-hardening in the Al-Mn-Cu alloys. Fe only increases the strength. An addition of 0.6% Mn materially improves the absolute strength values. The relatively large influence of Mn is augmented by Si but counteracted by Fe. None of the 3 elements Fe, Si or Mn is necessarily required for the age-hardening of duralumin at room temperature, principally produced by Mg. An additive effect of all 6 constituents does not take place, but only in case of Fe + Si, to a small extent and in case of Si + Mn to a more pronounced degree. The author in conclusion confronts his results with publications of other investigators along these lines. EF(27)

**Alloy Cast Irons—Molybdenum Cast Iron. (Le Ghise Speciali con Particolare Riquardo a quelle al Molibdeno.)** I. Musatti & G. Calbiani. *La Metallurgia Italiana*, Vol. 8, June 1930, pages 649–669.

Bibliography, 66 references, 9 tables, 9 diagrams, 14 micrographs. Studies were made on cast irons containing, respectively: Al, Ti, Ni, Cr, V, W, U, Co, Cu and Mo. Particular attention is given to new cast iron containing Mo, which was studied for its technological and mechanical properties. From the studies made it was found that the effect of Mo on cast iron ie noticeable in alloys containing up to 1.5% Mo. Mo increases the tensils strength about 75% and the resistance to compression about 100% for pearlitic cast irons having the same chemical composition. Mo improves noticeably the resistance to wear and to heat; does not seem to increase the resistance to corrosion. GTM(27)

**The Effect of Phosphorus on the Strength of Admiralty Gun-Metal.** H. C. Dews (Deweance & Co.). *Institute of Metals, Advance Copy* No. 532 (1930) 12 pages.

Samples of Admiralty gun-metal (10% tin, 2% zinc, 0.5% lead, balance copper) containing from 0.002–0.131% phosphorus were cast in green sand molds. Each alloy was cast at several different temperatures. Tensile strength, elongation, Brinell hardness and density were determined on each sample. Curves in which the tensile strength and elongation for each alloy are plotted against casting temperature prove that casting temperature has a profound effect on these 2 properties. Judged by the properties of the alloys cast at the optimum temperatures phosphorus up to 0.04% has little effect on the tensile strength and elongation, from this percentage to 0.07% both values fall rapidly, and with increasing phosphorus additions they show little or no change. The drop in tensile strength is from about 21–17.5 tons/in.$^2$ and elongation from about 33–23%. In the 0.065% phosphorus alloy, phosphide areas could be detected under the microscope. There is practically no change in density below 0.06% phosphorus. JLG(27)

## INSTRUMENTS & CONTROLLERS (28)

**The Thermo-Potentials of Chromium-Nickel Alloys. (Ueber die Thermokräfte von Chrom-Nickel-Legierungen.)** *Zeitschrift Verein deutscher Ingenieure*, Vol. 74, Jan. 11, 1930, page 50.

According to experiments carried out by F. Bauerfeld for his doctor-dissertation (Münster 1928) a thermo-couple consisting of a chromium-nickel alloy with constantan is particularly suitable for technical purposes as it can be used even for temperatures as high as 1200° C and gives 40–60 micro-volt per ° C. This couple is very constant for continuous operation. The thermo-potential increases almost linear with increasing temperature and with increase of chromium up to 10% contents, after that it decreases again. Ha(28)

**The Application of the Thermo-Magnetic Analysis on the Study of Some Iron Minerals and Their Oxides. (Anwendung der thermomagnetischen Analyse auf das Studium einiger Eisenmineralien und deren Oxyde.)** J. Hugget & G. Chaudron. *Korrosion und metallschutz*, Vol. 6, April 1930, pages 79–82.

The new instrument constructed for thermo-magnetic analysis by Chaudron-Forestier is applied to the study of some iron minerals and oxides. EF(28)

**Automatic Regulation of Electric Furnaces in the Foundry. (La régulation automatique des fours électriques de fonderie.)** A. Levasseur. (École superieure d'Electricite.) *Revue Générale de l'Electricité*, Vol. 27, April 26, 1930, pages 665–670; *Arts et Metiers*, Vol. 83, May 1930, pages 193–200.

Part of a lecture on construction and use of electric furnaces, delivered before the Association Technique de Fonderie, May 4, 1929, and published in full in Bulletin de l'Association Technique de Fonderie, Vol. 3, Dec. 1929, page 478–493. Outlines the principle of pyrometric regulation, and describes pyrogalvanometric and pyropotentiometric regulators. Discusses the different equations for automatic regulation. Describes the Brown, Boveri hydraulic piston regulator, and the Sécomet-Vastel electric motor regulator. MS(28)

**A Simple Color-Pyrometer. (Ein einfaches Farbpyrometer.)** G. Naeser. *Mitteilungen Kaiser Wilhelm Institut für Eisenforscung* 1929, Vol. 11 (Report 140) pages 373–385; *Stahl und Eisen*, Vol. 50, Feb. 27, 1930, page 264.

This new type of optical pyrometer is suitable for measuring temperatures above 900° C. and eliminates personal errors in readings which have their influence on other types of optical pyrometers. The main feature of the instrument is a precision color glass with variable color density. In sighting a hot specimen the change of color from red to green is indicated by a mixed color, almost white, giving the correct temperature of the specimen. Test results with the new instrument are given. GN(28)

**New Total Radiation Optical Pyrometers. (Nouveaux pyromètres optiques à radiation totale.)** S. Held. *Revue Générale de l'Electricité*, Vol. 27, June 21, 1930, pages 979–991.

Describes two types designed by the author. A chain of thermo-electric couples is used in the first. The second which is called an "optico-magnetic" pyrometer, makes use of the variation in magnetic susceptibility with temperature of certain Ni alloys. Two elements composed of this alloy are placed in a magnetic field, one being exposed to the heat rays, and the other forming the opposing couple. Discusses the theory of its operation. MS(28)

**Control by Using Light Rays.** J. V. Breisky. (Westinghouse Electric & Mfg. Co.) *Iron Age*, Vol. 125, April 24, 1930, page 1231.

Abstract of article before the Metropolitan section of American Electric Railway Association held in New York. Described temperature determination of hot steel by means of photo-electric cell. The "electric eye" readily indicates temperatures from 1300° F. up to highest heat encountered. Another application is the automatic control of lighting in factory, office, or school. VSP(28)

**On the Influence of Atmosphere, Temperature and Material of Protection Tubes on the Stability of Platinum Thermocouples. (Ueber den Einfluss von Glühatmosphäre, Glühtemperatur und Schutzvorsbaustoffen auf die Beständigkeit von Thermoelementen.)** F. Stäblein & J. Hinnüber. *Archiv für Eisenhüttenwesen*, Vol. 3, June 1930, pages 781–785; *Stahl und Eisen*, Vol. 50, July 31, 1930, pages 1089–1090.

The platinum wire of platinum thermocouples should always be protected by a protective tubing for practical use. Primary tests proved that the influence of various gases can be neglected for temperatures up to 900° C. The main tests were carried up to 1000° C.; the influence of gases was found to be decreasing in the following order: hydrogen, carbon monoxide, carbon dioxide, air. The influence of protective tubes was also examined. Reducing gases in the presence of metals, metal oxides and silicates destroy the noble metals. Tests prove that the destructive materials have to be present first as vapors. Gases themselves have no essential influence on the destruction of thermocouple wires. The picking up of foreign materials was proved by an increase of electric resistance and weight. The change of the mechanical properties of used thermocouple wires was studied by bending tests. Platinum wire used with protective tubing in hydrogen atmosphere stood 45 bends whereas the same wire used in air without protection stood 80 bends The corresponding figures for platinum-rhodium wire are 35 and 55, respectively. In using thermocouples in illuminating gas the platinum-rhodium wire is quickly covered with soot. GN(28).

## EFFECT OF TEMPERATURE ON METALS & ALLOYS (29)

**Carburizing and Graphitizing Reactions between Iron-Carbon Alloys, Carbon Monoxide and Carbon Dioxide.** M. L. Becker. *Journal Iron & Steel Institute*, May 1930, *Advance Copy* 3, 24 pages; *Engineering*, Vol. 129, May 16, 1930, pages 642–643.

The paper is the result of an investigation into some of the abnormalities in the behavior of cast iron at elevated temperatures, and includes suggestions for ways of inhibiting growth and scaling. Oxidation, carburization and graphitization of steels and irons in the presence of CO and $CO_2$ are briefly discussed. A new method is described by which equilibria between the gases and carbon or steel may be studied. In this method, the partial pressure of $CO_2$ in the reacting gas is controlled by varying the temperature of a dissociating carbonate. By subtracting the known $CO_2$ tension from the measured total pressure, the CO tension is obtained. From these values the composition of the gas in equilibrium with carbon or steel may be deduced. The method has been used to determine the compositions of the gas in equilibrium with steels of varying carbon content. The results are plotted for a number of temperatures and broadly speaking, this temperature-composition diagram confirms that already published by Johansson and von Seth. The composition of the gas in equilibrium with graphite has been found to vary over a range of temperature from 650–1000° C. in accordance with determinations made by previous workers. The gas in equilibrium with iron carbide plus saturated solid solution is found to be richer in CO than that in equilibrium with graphite at the same temperature. The carbon vapor pressure of iron carbide must, therefore, be higher than that of pure carbon, at any rate between 650° and 1000° C. It would, therefore, appear that graphite is stable with respect to iron carbide over this range of temperature. The influence of silicon, manganese, nickel and chromium upon the equilibria has also been investigated. AEH&LM(29)

**The Effect of Temperature Upon the Torsional Modulus of Spring Materials.** F. P. Zimmerli, W. P. Wood & G. D. Wilson. *Preprint* No. 38, June 1930 Meeting, *American Society for Testing Materials*, 11 pages.

Torsional moduli were obtained over a range of temperatures and by 2 methods for high carbon spring steel, chromium vanadium, silico manganese, unnitrided Si-Al-Mo nitriding steel, 18–8 Cr-Ni austenitic, and high speed steels, for phosphor bronze 2:1 brass and monel metal. On the first run all materials showed higher moduli at 80° C. than at room temperature. This is ascribed to release of internal stress from cold work due to coiling. When internal stress was not present the modulus fell off with increasing temperature. Due to the jog in the curves coming from release of internal stress it is difficult to trace the actual effect of cooling to −90° C., though such tests were made. In general, on steels, the modulus was higher at sub-zero temperatures. At about 300° C. the modulus was a little above 10,500,000 lbs./in.$^2$ for high speed steel, unnitrided nitralloy, 0.65% C, 1% Mn steel between 9½ and 10½ million for 0.70–0.90% C steel with low Mn, for silico manganese and chromium-vanadium, while the 18–8 austenitic stainless showed only 9 million and monel 8½ million. The moduli of phosphor bronze and brass were not taken at 300° C., but at about 250° C. were, respectively, 5 and 3 million. Monel was far superior for high-temperature spring use to the other non-ferrous alloys tested. HWG(29)

**Flow Characteristics of Special Fe-Ni-Cr Alloys and Some Steels at Elevated Temperatures.** H. J. French, William Kahlbaum & A. A Peterson. *Bureau of Standards Journal of Research*, Vol. 5, July 1930, pages 125–183; *Advance Paper, American Society of Mechanical Engineers*, No. 5, June 9–12, 1930, 32 pages.

The results of "creep" tests at different temperatures are given for 3 groups of alloys. The 11 metals in the first group included commercial alloys of nickel, chromium and iron, both with and without tungsten, and low chromium steels containing also tungsten, vanadium or molybdenum. The second group comprised 2 carbon steels, a 3½% nickel steel and 2 low nickel chromium steels which were tested only at 700° F.; the 12 alloys of the third group were melted in a high-frequency induction furnace, and their compositions were selected to show the general trends at 1,000° F. in the load-carrying ability of castings of the nickel–chromium–iron system. A metallographic study of the creep-test specimens revealed intercrystalline weakness in some of the wrought nickel-chromium-iron alloys especially at temperatures between 1160° and 1390° F. A study was also made of the effect of deformation in the creep tests at different temperatures on the hardness and impact resistance of a chromium vanadium steel at atmosphere temperatures. (29)

**Steel at Elevated Temperatures.** Albert Sauveur. *Transactions American Society for Steel Treating*, Vol. 17, Mar. 1930, pages 410–448.

The 4th Edward De Mille Campbell Memorial Lecture presented before 11th Annual Convention, Sept. 1929. Curves showing the tensile strength and Brinell hardness of electrolytic iron and steels from 0.10–0.75% C. at temperatures up to 1000° C. are given from earlier work. Normalized iron and steel increase in strength and hardness through the blue heat range from 250° to 400° C. (depending upon the carbon content) this increase apparently being due to a strengthening of the ferrite. Hardness produced by straining beyond elastic limit is maximum if done in blue heat range or if the steel is heated to this range after straining. Further data from twisting small specimens at high temperatures are given, comprising torsional strength, angle of rupture (ductility), "factor of stiffness" (stress/strain), and time-strain diagrams. Armco iron and steels from 0.12–1.17% C. were tested as well as 2 austenitic Ni-Cr, 3 non-austenitic Cr steels, and S.A.E. 3130. Maximum strength and minimum ductility not always coincident in blue heat range. Discontinuities in curves at thermal critical points call for clearer conception of the latter. Time-strain curves show behavior of specimen under plastic deformation. Correlation of twisting test results with results of long time creep tests performed by Prof. F. H. Norton at M.I.T. is given. WHK(29)

**The Influence of Temperature Upon the Notch Toughness and Hardness of Aluminum Alloys. (Versuche über den Einfluss der Temperatur auf Kerbzähigkeit und Härte von Aluminium legierungen.)** W. Schwinning & E. Fischer. *Zeitschrift für Metallkunde*, Vol. 22, Jan. 1930, pages 1–7.

The writers report on extensive investigations with Al-alloys in the As delivered, cold worked and stored condition at temperatures between −190° and +200° C. The temperatures were attained by a mixture of snow and salt, ether and carbonic acid and an oil bath. The hardness values indicate an increase in resistance to deformation with falling temperatures. The Brinell hardness of Lautal and 2 samples of Al (99.5% and 98–99%) show that the hardness of Lautal is greater than that of Al over the whole temperature range, but the loss in hardness is more pronounced in Lautal than in Al. The notch impact values of Duralumin, Lautal, Constructal and Scleron are given between −40 and 100° C, showing lower values with increasing temperatures except those for Lautal which fall from −40–0°, but rise from 0–100°. The impact hardness of Al, a 56% Cu brass, Lautal and Scleron are given. Both Al-samples show a very considerable decrease with temperature, whereas brass shows only a slight decrease. Lautal increases from −200–0° and falls slightly from 0 to 200°. Scleron remains constant from −200–80°, then rises sharply to 180°. The behavior of the age-hardening Al alloys is contrasted to that of age-hardening steel. The aging of cold-worked Al alloys is not accompanied by an increased resistance to deformation as is the case with the steels. Furthermore the influence of temperature on bending strength of sheets as investigated. An appreciable increase of bending capacity of Lautal was experienced in the range of 50–100° although other properties do not change largely in this range. EF(29)

## LEACHING (30)

**Acceleration of Extraction of Soluble Copper from Leached Ores.** Morris Guggenheim & John D. Sullivan. *Technical Paper* 472, *United States Bureau of Mines*, 1930, 30 pages.

The removal of copper from rocks by alternate wetting and drying was studied. The maximum rate of extraction of water-soluble copper was usually obtained by a half or one hour drying period after a similar washing period. Extractions of 50 and 90% of total water-soluble copper obtained in 8 and 71 hrs., respectively, in chemical diffusion tests, were obtained in 2 and 17 hrs. by alternate wetting and drying when the cycle was a half hour wash and one hour dry. Extraction is accelerated by moving air, increased temperature and particles between 2 and 3 inches in size. (Contains 4 footnote references.) AHE(30)

**Chemistry of Leaching Chalcocite.** John D. Sullivan. *Technical Paper* 473, *United States Bureau of Mines*, 1930, 24 pages.

Chalcocite can be leached with $Fe_2(SO_4)_3$. About 1.7–1.8 parts of ferric iron are reduced to the ferrous condition for each part of copper extracted. The rate of dissolution is independent of the strength of the reagent provided an ample amount is present. The concentration should be kept as low as possible since (1) ferric salts reduce current efficiency and necessitate higher current densities in electrolytic precipitation and (2) iron is consumed by ferric salts in cement copper plants. The rate of dissolution of chalcocite is independent of the acid strength if the ferric iron concentration remains constant. Acid is desirable to dissolve the oxidized copper minerals present and so save the $Fe_2(SO_4)_3$. The rate of dissolution of chalcocite is also independent of particle size from 10 to minus 200 mesh. The rate is markedly affected by temperature. The reaction takes place in two steps. (1) $Cu_2S + Fe_2(SO_4)_3 = CuSO_4 + 2FeSO_4 + CuS$ and (2) $CuS + Fe_2(SO_4)_3 = CuSO_4 + 2FeSO_4 + S$. The first reaction is more rapid than the second. The CuS does not remain constant but undergoes a change as more copper is dissolved until the atomic ratio of Cu : S = 0.9 or less. (Contains 13 footnote references.) AHE(30)

**Dissolution of Various Oxidized Copper Minerals.** J. D. Sullivan. *Report of Investigations* 2934, *United States Bureau of Mines*, 1929, 9 pages.

Experiments have shown that approximately 100% of the copper in the oxidized copper minerals azurite, malachite, chrysocolla and tenorite is soluble in 1 hour in $H_2SO_4$ or acidified $Fe_2(SO_4)_3$. In 1 or 2% neutral $Fe_2(SO_4)_3$ the dissolution is somewhat slower, but in nearly every instance the minerals are completely decomposed in 24 hours or less. The rate of dissolution in 5% neutral $Fe_2(SO_4)_3$ is about the same as in $H_2SO_4$. (Contains 2 footnote references.) AHE(30)

**The Dissolution of Cuprite in Sulphuric Acid and in Ferric Sulphate Solution.** John D. Sullivan & G. L. Oldright. *Report of Investigations* 2967, *United States Bureau of Mines*, 1929, 9 pages.

When cuprite in pieces up to 4 mesh in size is treated in open bottles with $H_2SO_4$, approximately 100% of the total copper is converted into the soluble sulphate in 20 days. For sizes of 100 mesh or smaller, 24 hours is sufficient for complete dissolution. When treated with acidified $Fe_2(SO_4)_3$, particles up to 3 mesh in size entirely dissolve in 8 days; in 3 days 99% is dissolved. For particles of 100 mesh or smaller, 1 hour is sufficient for complete dissolution in either acidified or neutral $Fe_2(SO_4)_3$. Oxygen is necessary to complete dissolution. The mechanism of the dissolution of cuprite in $H_2SO_4$, neutral $Fe_2(SO_4)_3$ and acidified $Fe_2(SO_4)_3$ is discussed. (Contains 5 footnote references.) AHE(30)

**Leaching Silver in Unroasted Tailings with Ferric Salts in Saturated Brine.** G. L. Oldright. *Report of Investigations* 2981, *United States Bureau of Mines*, 1929, 4 pages; *Metal Industry* (London), Vol. 36, Mar. 7, 1930, page 280.

Over 80% of the silver and practically all the lead in the unroasted flotation tailing from certain Utah ores were extracted by leaching for 2 hours with a warm brine solution containing a ferric salt. (Contains 8 footnote references.) AHE(30)

## REDUCTION METALLURGY (31)

**The Noranda Smelter.** W. B. Boggs & J. N. Anderson. *Canadian Mining & Metallurgical Bulletin*, No. 215, March, 1930, pages 362–405.

A thorough description of the plant. AHE(31)

**Possibilities of Production of Radium and Vanadium from Carnotite.** H. A. Doerner. *Industrial & Engineering Chemistry*, Vol. 22, Feb. 1930. pages 185–189.

When an ore which is treated for its vanadium content contains as much as 1% uranium oxide ($U_3O_8$), an uranium concentrate should be recovered as a by-product and saved for possible future treatment for radium. Analysis of production costs leads to the conclusion that mechanical concentration of low-grade ore might be an important factor in reducing the cost of radium. As applied to a shipping ore, no proved method of treatment stands out above others for cheapness of operation or efficiency, and there is small probability that any new method will greatly change the cost of extracting the radium from an ore. With the possible exception of the fluoride method of Fleck and Haldane, only direct leaching methods are applicable to a dust concentrate from a low-grade ore. As compared to an ore, the processing of such concentrates requires more reagents and involves more difficult filtrations. For carbonaceous ores and for the nitric acid method of extracting radium, preliminary roasting of the ore is recommended as having distinct advantages. MEH(31)

**Gas-Solid Contact in the Shaft of a 700-Ton Blast Furnace.** S. P. Kinney & C. C. Furnas. *Report of Investigations* 2939, *United States Bureau of Mines*, 1929, 10 pages.

The gas velocity is fairly high along the wall, drops off to a minimum about 2 feet from the wall and then rises to a high velocity at the center, probably caused by the batter. At the 3-foot plane, above the batter line, there is no high wall velocity. In this plane the maximum velocity is about 6 times the minimum. In general, the temperature curves follow the gas-velocity curves. The $CO_2$ bears an inverse ratio to gas velocity. The greatest static pressure occurs in the center of the furnace. The distribution of the particles of various sizes across any plane is very uneven near the top of the furnace but tends to improve progressively toward the bottom due to the apparent flow of stock toward the combustion zones in front of the tuyères. A uniformity coefficient is derived and discussed. (Contains 5 footnote references.) AHE(31)

**Ore Size and Blast-Furnace Economy.** S. P. Kinney. *Report of Investigations* 2983, *United States Bureau of Mines*, 1930, 4 pages.

Operation with 2 or 3 sizes of ore, where each size was charged alone and in rotation with the others (layer filling) resulted in decreased coke consumption and increased iron production when compared with results with one size only. In making foundry iron, 2 sizes saved over 300 pounds and 3 sizes almost 500 pounds of coke/ton of iron, at the same time producing 87 and 110 tons more iron/day, respectively. Similar improvements for basic iron gave 335 and 437 pounds of coke/ton of iron saved using 2 and 3 sizes, respectively, with 62 and 82 more tons of iron made per day. A decrease in the overall size of the ore used played an important part in the improvement. A greater burden can be carried with layer filling than without because of better gas-solid contact. The $CO/CO_2$ ratio in the top gas when operating with 1, 2 and 3 sizes of ore was 2.68, 2.20 and 1.54, respectively, indicating the fuel economy with increased number of sizes. AHE(31)

**Smelting in the Lead Blast Furnace. I. A Method for Approximating the Form of the Lead in Slag and Other Products of the Lead Blast Furnace.** G. L. Oldright & Virgil Miller. *Report of Investigations* 2954, *United States Bureau of Mines*, 1929, 8 pages.

Dissolve a 0.5–5 gram sample in 25 cc. of ammonium acetate, dilute to 100 cc., boil 10 minutes, filter and wash. The filtrate contains lead as oxide, sulphate or basic sulphate. Add 10–20 cc. of 10% solution of $AgNO_3$ to the residue, treat 1 hour cold, filter and wash. The filtrate contains the lead present as sulphides, the residue the lead silicates. The filtrates are analyzed for lead and the mineral percentages calculated. (Contains 14 footnote references.) AHE(31)

**Smelting in the Lead Blast Furnace. II. The Gases from the Top of the Lead Blast-Furnace.** G. L. Oldright & Virgil Miller. *Report of Investigations* 2957, *United States Bureau of Mines*, 1929, 18 pages.

Very little sulphur is removed from the charge in the furnace gases. Top gas (if undiluted with air) is of sufficient calorific value to be used as a fuel. Its CO content differs little from that of iron blast-furnace gas. Variations of temperature and composition of top gases are similar to those that would occur in a gas producer having a variable height of combustion zone. Highest top temperatures accompany the highest $CO_2$. "Hot top" is caused by the combustion zone rising too high in the charge. Analyses of 150 samples of gas from 21 positions at the top of a lead blast furnace are given. (Contains 6 footnote references.) AHE(31)

**Smelting in the Lead Blast Furnace. III. Rate of Descent of Stock Column and Formation of Accretions.** G. L. Oldright & Virgil Miller. *Report of Investigations* 2963, *United States Bureau of Mines*, 1929, 17 pages.

The rate of smelting is fastest toward the front. Accretions in the shaft contribute greatly to the irregularity of stock column descent. Accretions are largest where the rate of descent is least. In general, they build up at the ends of the furnace, are thickest at the center line which is furthest from the tuyères and are thinner on the sides. Excepting material chilled directly on the water jackets near the tuyères, accretions start to build at the zone of incipient fusion some 6 feet above. There is more difficultly fusible material such as zinc oxide, lime, silica and iron on the outside of the accretion than inside. Lead sulphide also concentrates here. Metallic lead and sulphides, particularly zinc sulphide, were concentrated in the interior. There is enough sulphur to combine chemically with copper, zinc and part of the lead and iron as sulphide. The balance consists of lead in various forms and of solid or slag-forming ingredients of the charge. The zone in the crucible most nearly free from accretions is at the front next to the lead well. The volume and temperature of the fused material delivered to the various parts of the crucible control local temperatures and, therefore, the local amounts of accretion formed. The temperature of the molten lead in the crucible varied from 815–971°. Since the melting point of the sulphides ordinarily found are all above 1113°, the presence of sulphide material controls the formation of crucible accretions. (Contains 7 footnote references.) AHE(31)

**Smelting in the Lead Blast Furnace. IV. Composition and Temperature of the Gases at the Tuyère Zone.** G. L. Oldright & Virgil Miller. *Report of Investigations* 2965, *United States Bureau of Mines*, 1929, 27 pages.

The oxygen in the blast penetrates the charge to the average distance of about 18 inches from the tuyère nose. No zone was found in which oxygen and carbon dioxide were both absent. Hydrogen is negligible. The maximum concentration of carbon monoxide was 88.4% with no oxygen, 3.6% carbon dioxide, 0.9% hydrogen and 7.1% nitrogen. Carbon monoxide decreased steadily from the front to the rear of the furnace. Temperature dropped with carbon monoxide concentration. Tapping reduces temperature and carbon monoxide. Carbon dioxide and carbon monoxide varied approximately together. (Contains 17 footnote references.) AHE(31)

**Smelting in the Lead Blast Furnace. V. Effect of Conditions at Various Tuyères on the Form of Lead and Composition of the Slag.** G. L. Oldright & Virgil Miller. *Report of Investigations* 2966, *U. S. Bureau of Mines*, 1929, 7 pages.

The amount of lead silicate increases sharply from the slag tap to the middle of the furnace because of the drop in temperature and carbon monoxide concentration. Toward the back, the amount drops steadily because of the lower speed of charge movement in this part of the furnace which gives reducing agents sufficient time to act. After fusion, lead silicate moves so rapidly past the tuyères that carbon monoxide alone is ineffective. Lime or iron assists by replacement. At high temperatures slag contains more lime and less lead combined with silica. Iron in slag increases with decreasing temperature. AHE(31)

**The Form of Copper in Converter Slag.** F. S. Wartman & W. T. Boyer. *Report of Investigations* 2985, *United States Bureau of Mines*, 1930, 16 pages; *Metal Industry* (London), Vol. 36, May 9, 1930, pages 504–507.

Chilled slag is more difficult to grind than slowly-cooled material. In the former, the copper-bearing compounds are so finely disseminated that they are not freed at 200 mesh; in the latter they are largely free at 150 mesh. Neither $AgNO_3$, $H_2SO_3$, nor a mixture of $H_2SO_3$, HF and pyrogallic acid will distinguish between prill and dissolved copper or between oxide and sulphide copper in the slag with an accuracy greater than 10 % of the total copper content. The copper content of the first slag skimmings from the converting of low- or medium-grade matte is in the form of sulphide or metallic copper. Slags skimmed near the white metal stage may contain an appreciable proportion of its copper content in the oxide form. The whole body of the slag produced in converting a matte containing 30% copper will have about 90% of the copper content in the metallic or sulphide form. (Contains 14 footnote references.) AHE(31)

**Blast-Furnace Construction and Operation.** *Iron & Coal Trades Review*, Vol. 120, April 18, 1930, pages 636–637.

Reviews the trend in furnace practice in America. Average number of furnaces in blast in 1929 was 205. The daily average per stack was about 575 tons. A hearth diameter of 25 feet will usually produce 1000 tons per day. Discusses hot-blast stoves, gas cleaning equipment, the use of cooling plates above the mantle, and other equipment. RHP(31)

**Method for Comparison of the Size of Materials Used in Blast-Furnace Burdens.** S. P. Kinney. *Report of Investigations* 2982, *United States Bureau of Mines*, 1930, 4 pages.

A method is described by which the average particle size of individual materials and of the burden as a whole can be determined. AHE(31)

**Standardization of Shaft Furnaces for Handling Lead Ore. (Rationalisation du four a cuivre pour traitement du mineral de plomb.)** N. C. Kiriacou. *Revue de Metallurgie*, Vol. 27, Mar. 1930, pages 113–124.

The use of shaft furnaces for smelting lead concentrates requires the addition to the burden of coke to loosen it. This can be eliminated by sintering roasting of the concentrates. For the best results all carbon must be transformed into CO, preferably in the melting zone. The true composition of the gas as formed is quite complicated. The presence of water vapor is necessary because without it the combustion is slow and imperfect. At the tuyère zone C changes completely into CO. Lowering the temperature does not affect the reactions. Volatilization is prevented by greater Pb concentrations. With 10% Pb in the burden yearly losses by the volatilization were 12.3%, with 60% Pb they were reduced to 0.3%. Reducing power of gases varies greatly and with the introduction of the fuel through tuyères recording instruments become necessary. Several shaft furnaces using pulverized coal are referred to but none for Pb smelting. A simple charging apparatus preventing gas and smoke losses is described. Bag houses are generally used for smoke purification. JDG(31)

**Some Important Factors in Sponge Iron Production.** EDWARD P. BARRETT. *Report of Investigations* 2955, *United States Bureau of Mines*, 1929, 4 pages.

The rate of reduction of iron oxides and the factors affecting this rate, the penetration of heat through crushed iron ore and carbonaceous material and the absorption of sulphur by sponge iron are discussed. (Contains 6 footnote references). AHE(31)

## GENERAL (0)

**From Aluminum Ingots to Kitchen Utensils.** J. B. NEALEY. *Industrial Gas*, April 1930, Vol. 8, pages 14–15; *American Gas Association Monthly*, Vol. 13 April 1930, pages 164–165.

A brief illustrated description of the manufacture of stamped aluminum kitchen utensils from the rolling of the sheets to the forming of the ware. WHB(0)

**Heresy.** H. W. GILLETT. *Metals & Alloys*, February 1930, Vol. 1, pages 359–360.

The injustices of the present patent situation and its possible elimination as a remedy are discussed. ESC(0)

**Research Precision vs. Pedigree Steel.** G. M. EATON. *Metals & Alloys*, March 1930, Vol. 1, pages 415–416.

A discussion relative to the desirablility of marking the ingot location of steel so that the user may apply the inferior grades characteristically obtained in portions of the ingot to less hazardous purposes. Proposals are made regarding production methods for segregation of billets. Present-day engineering developments are reaching a stage which demands Pedigree Steel. ESC(0)

**Sentiment and Research.** *Metals & Alloys*, May 1930, Vol. 1, page 491.

An editorial. A plea for the human interest elevation of research publications is made. It is maintained that the motives of research are for the betterment of mankind, that the drama, the poetry and the generous motive which is concealed in the undertaking deserves its place in the story of its struggles. ESC(0)

**Locomotive Forgings.** LAWFORD H. FRY. *Transactions American Society for Steel Treating*, Jan. 1930, Vol. 17, pages 1–53; *Iron & Coal Trades Review*, Vol. 119, Oct. 11, 1929, page 542.

Paper presented before the Eleventh Annual Convention, American Society for Steel Treating, September 1929. Includes discussion. In the production of high quality forgings of the size required for locomotives the importance of all the steps from the melt onward is stressed. The acid open hearth process is held to be superior in obtaining greater freedom from oxide contamination. For the highest quality steel no additions should be made to the ladle. In order to reduce the tendency toward segregation it is held that the ingot should be no larger than necessary, a reduction of three to one from ingot to forging being now considered sufficient. The "hot-top" type of ingot is favored. The forging process is described and the resulting structures are illustrated by photomicrographs. Banded structure (ferrite bands, clearly distinguished from fibrous structure due to inclusions) is held to be not definitely injurious. The types of steel used are: plain carbon, carbon-vanadium, and chromium-vanadium or chromium-nickel, the last two being not much employed. A recent addition is a low carbon, 2% nickel, steel of moderately high manganese, introduced to secure high ductility. Heat treatment after forging to refine the grain is generally normalizing followed by tempering, the present tendency being to get away from quenched forgings for locomotive service. The boring of large round sections is advocated to increase the efficiency of the heat treatment. The author discusses the relation between the tensile properties commonly measured in acceptance tests, e. g., ultimate tensile strength, yield point, elongation in 2 inches, and reduction of area. For steels of tensile strengths from 85,000 – 93,000 lbs./in.$^2$ it is recommended that the product of the tensile strength by the elongation be not less than 2,130,000. See *Metals & Alloys*, Jan. 1930, Vol. 1, page 343. RHP & WHK(0)

**Industrial Progress Made through Research, Its Economic Importance.** WILLIS R. WHITNEY. *Metals & Alloys*, Feb. 1930, Vol. 1, pages 370–372; *Blast Furnace & Steel Plant*, Vol. 8, Feb. 1930, pages 370–372.

A paper delivered at the World Engineering Congress in Tokio, Oct. 1929. Research is a parent of industrial growth, the other being a will to live better. There was a time when work was enforced by hunger or other animal needs. There grew up a counter trait described best as interest, inquisitiveness and constructive appreciation. This constructs pleasure and happiness out of experiment and research. This growth of creative spirit has reached out to a point where men now heartily enjoy working as they never had to work before because of creative or artistic urge. Organizations have developed to permit each member to be a specialist of some sort. Research received its earliest impulses from those who spent the most time in constructive thinking. Perhaps in no one case is the effect of academic study more in evidence than in the chemical industry. Germany established enormous and varied industries on the researches of countless young doctors of philosophy carried out over a period of fifty years. The study of physical laws likewise brought out the steam engine, the spinning frame, the printing press, the electric generator and countless other advancements. Research is something designed to discover untested materials and processes, to bring out better use of old materials, to reveal new wants, and actually predetermine new needs. Bergson wrote that the essential objects of science is to enlarge our influence over things. Medicine, biology, physics and astronomy all have profited by scientific advance. At the beginning of this century there were practically no industrial research laboratories in the United States. Now a recent report of the National Research Council lists a thousand laboratories independent of colleges and government bureaus. Three hundred were listed in 1920. Every industry interested in future growth should devote a small fraction of its profits to scientific research. MS & ESC(0)

**The Contribution of Science to the Iron and Steel Industry.** A. D. LITTLE. *Preprint*, May 1930 Meeting, *American Iron & Steel Institute*, 16 pages; *Engineering*, Vol. 129, June 6, 1930, page 751.

Quotations and citations from the work of others showing the value of research to the steel industry. HWG & LM(0)

**Recent Metallurgical Research.** S. L. ARCHBUTT. *Iron & Coal Trades Review*, Vol. 120, April 11, 1930, page 599.

Very brief abstract of a paper entitled: "Recent Metallurgical Research in Relation to Marine Engineering" and read before the Institute of Marine Engineers, London, April 8, 1930. RHP(0)

**Aeronautical Progress in Great Britain.** H. E. WIMPERIS. *Journal Aeronautical Society*, Vol. 33, Oct. 1929, pages 935–946.

The paper dealing with aircraft developments in Great Britain contains reference to metallurgical research on ferrous and non-ferrous materials of construction which has been undertaken by or in collaboration with aeronautical engineers. The marked changes which have been effected in aircraft structural steels have included the utilization of the high mechanical properties of certain of the nickel-chromium steels. Maximum stresses up to 190,400 lbs./in.$^2$, combined with a good degree of ductility, are obtainable in these steels, which offer valuable possibilities to the aircraft engineer.—*Bulletin British Cast Iron Research Association.* (0)

**Important Developments in the Gray-Iron Industry.** ARTHUR J. TUSCANY (GRAY IRON INSTITUTE, INC.). *American Machinist*, Vol. 72, Mar. 6, 1930, pages 415–416.

Abstract of a paper presented at the annual meeting of the American Ceramic Society and the American Refractories Institute, Feb. 19, 1930, Toronto, Canada. RHP(0)

**Aluminum Foil and Powder.** *Metal Industry*, N. Y., Vol. 28, April 1930, pages 159–161.

Al foil is produced by casting rolling blocks into iron molds. Metal is poured at 750–770° C. Care must be exercised to avoid inclusion of dross and oxide. Rolling is done at about 420° C. Rolled material is coiled up and rerolled after passing through guides on the rolls. Rolling is repeated 6 times until thickness is 0.04 mm. Hammering operation is accomplished by pneumatic hammers each weighing 300 lbs. Losses in this process are considerable due to cutting to size, hammering and sticking together of foil when finished. Al-foils produced by rolling the sheets are greased and rolled two at a time down to a thickness of 0.02 mm. and four together down to 0.01 mm. Discusses applications and properties of Al foil. Al powder used principally in Al paint is produced from scraps and waste resulting from the manufacture of foil. Scraps of foil are broken up by hammering into minute shreds. The powder is passed through a silk sieve of 200 mesh. What will not pass through this sieve is returned to stamping mill. Material passing through sieve is graded. Metallized paper using Al powder is extensively used in packing tea, food-stuffs, etc. Al foil is also used in combination with paper and cardboard for book covers, wall papers, etc. VSP(0)

**Some Comments on Steel Specifications.** J. JOHNSTON. *Preprint*, May 1930 Meeting, *American Iron & Steel Institute*, 19 pages; *Engineering*, Vol. 129, June 6, 1930, page 749; *U.S. Steel Quarterly*, Apr.-Jun. 1930, pages 66–71.

Argument against imposing both chemical composition and mechanical properties in specifications for steel. Plea for unification of specifications, elimination of needless specifications and for specifications built on definite technical facts rather than opinions. HWG & LM(0)

**Steel Forging Containing Nickel.** CHARLES MCKNIGHT (INTERNATIONAL NICKEL CO.). *Iron Age*, Vol. 125, Mar. 20, 1930, pages 851–852, 902.

Taken from a paper delivered at semi-annual meeting, in New York, Feb. 7, of American Society for Steel Treating. Deals with the manufacture, uses, analyses, heat treatment and properties of nickel alloy steel forgings larger than 4 in. in diameter. Contains tables giving the chemical and physical properties of nickel alloy steel forgings, also specifications. VSP(0)

**Promotion of General Use of Specifications for Copper Alloys in Ingot Form.** *Report of Special Commitee, Preprint* No. 28, June 1930 Meeting, *American Society for Testing Materials*, 3 pages.

Over 600 specifications promulgated by various bodies are in use in the U. S. for copper alloys in ingot form. There are 40 different specifications for 85–5–5–5 differing in tolerances on Cu, Sn, Pb and Zn or on impurity contents, Ni, S, P, Sb, Fe, etc. These 40 certainly can be condensed into one. The Non-Ferrous Ingot Metal Institute is financing a study at the U. S. Bureau of Standards aimed at supplying data for agreement on a smaller number of ingot metal compositions and for development of equitable specifications. HWG(0)

## PROPERTIES OF NON-FERROUS ALLOYS (2)

**The Hall Effect, Electrical Conductivity and Thermoelectric Power, of the Lead-Antimony Series of Alloys.** EMLYN STEPHENS. *London, Edinburgh, & Dublin Philosophical Magazine & Journal of Science*, Vol. 9, April 1930, pages 547–560.

Gives several references in the footnotes. Discussion and summary of work which was done to determine the Hall effect, electrical resistivity, temperature coefficient of resistance, and the thermoelectric power of the lead-antimony series of alloys. Alloys were chill cast and the electrical resistivity at 0° C. was determined in this state. Resistivity was again calculated after annealing. Annealing was continued till no further variation was shown in the resistivity. The temperature coefficient of resistance, thermoelectric power and Hall effect were determined for the alloys in this final state. Each of the curves representing these effects is continuous and regular but there is no indication of a close relationship between any of them. Annealing reduced the resistivity of all the alloys. RHP(2)

**The Aluminium-Brasses.** R. GENDERS. *Journal Institute of Metals, Advance Copy* 520, 1930, 19 pages; *Engineering*, Vol. 129, Mar. 14, 1930, pages 357–358; *Engineer*, Vol. 149, Mar. 21, 1930, pages 320–321.

The author has examined the properties of ductile aluminum-zinc-copper alloys. He shows that in certain ranges of composition aluminum has a beneficial influence on brass in several ways, and gives enhanced resistance to corrosion and lessens oxidation at high temperatures. The composition of the alloys may be so arranged as to give a wide range of mechanical properties. Repeated remelting of the alloy had no apparent effect on these properties. AEH&LM(2)

**Properties of Locomotive Firebox Stays and Plates.** O. F. HUDSON, T. M. HERBERT, F. E. BALL & E. H. BUCKNALL. *Engineering*, Vol. 129, Jan. 3, 1930, pages 30–32.

Condensed from paper read before the Institute of Metals, Düsseldorf, Germany, Sept. 11, 1929. See *Metals & Alloys*, Feb. 1930, page 382. LM(2)

## PROPERTIES OF FERROUS ALLOYS (3)

**French Structural Steel.** *Iron & Coal Trades Review*, Vol. 120, Jan. 17, 1930, page 86.

A new type of constructional steel has been developed by the French Technical Office for the Utilization of Steel with the coöperation of eight of the leading steel works of the country. The chemical analysis is as follows: Cr, 0.4 – 0.6%; Cu, 0.3 – 0.5%; S < 0.06%; P < 0.07%. The content of carbon, silicon and manganese may be adjusted at the discretion of the company as long as the steel complies with the following specifications: elastic limit, to exceed 22.86 tons/in.$^2$; ultimate tensile strength, 31.75 – 38.10 tons/in.$^2$; elongation to exceed 22%; cold-bending test, the piece to bend round a mandril having a diameter of twice the thickness of the test piece, without cracking until the two halves are parallel. The copper content makes it more resistant to corrosion than ordinary steels. It may be worked easily and is suitable for many uses. RHP(3)

**Steam Piping of the New Central Plant of C. P. D. E. and Properties of Steel at High Temperatures. (La tuyauterie de vapeur de la nouvelle Centrale de la C. P. D. E.)** DESSUS, LECONTE & J. GALIBOURG. *Société Des Ingenieurs Civils de France—Memoires et Comptes Rendus des Travaux*, Vol. 82, May-June 1929, pages 479–538.

See *Metals & Alloys*, Jan. 1930, page 337. (3)

**The Permanent Growth of Gray Cast Iron.** WALTER E. REMMERS. *Technical Publication* No. 337, *American Institute of Mining & Metallurgical Engineers*, Feb. 1931, 11 pages.

Bibliography of 34 references. Other investigators have ascribed permanent growth of cast iron on repeated heatings to the formation of minute cracks, to oxidation, to the pressure of the occluded gases and to the decomposition of cementitite. By repeated heatings the author caused test pieces to increase as much as 42% in volume. Tests made by heating in a vacuum proved that growth could occur in the absence of gases, and other tests showed that increased time at maximum temperature increased growth. From these tests it is concluded that growth is due chiefly to precipitation, solution and reprecipitation of the graphite. Oxidation of the matrix and fracturing on heating and cooling may also account for some of the growth. JLG(3)

**Mechanical Properties of Some Structural Steels Hardened below the $Ac_3$ and above the $Ar_3$ Point.** WILLIAM R. ANGELL. (Naval Gun Factory.) *Transactions, American Society for Steel Treating*, Vol. 17, Feb. 1930, pages 262–272.

The author shows that in some cases where there is considerable hysteresis between the $Ac_3$ and $Ar_3$ points (particularly in alloy steels) it is possible to quench from just above the $Ar_3$ point and obtain physical properties as good as, or better than those obtained by quenching from above the $Ac_3$ point, provided, of course, that the $Ac_3$ point is exceeded in the heating cycle. With certain steels it is possible to cool slowly in the furnace over a range of 300 or 400° F. before quenching, the advantage claimed being that much lower stresses are set up at the lower quenching temperatures. Tensile, hardness and Izod data and micrographs are given for 12 of the steels investigated. WHK(3)

**High-Test Gray-Iron Castings.** Suggested revision of A.S.T.M. specification A 88-29, in Report of Committee A-3 on Cast Iron, *Preprint* 11, June 1930 Meeting, *American Society for Testing Materials*, 3 pages.

All classes of so-called semi-steels, pearlitic irons and special alloy irons, may be made by cupola, air-furnace, electric furnace or other generally approved process. When heat-treatment, heated molds or other expedients are used to modify the properties of the castings, the equivalent shall be used in the preparation of the test bars. The minimum load requirement for the transverse test is raised from 2250 lbs.–2500 lbs., and the minimum tensile strength from 28,000–33,000 lbs./in.². HWG(3)

**The Properties of Some Steels Containing Chromium.** A. R. PAGE & J. H. PARTRIDGE. *Journal Iron & Steel Institute*, May 1930, *Advance Copy* 2, 23 pages; *Engineereng*, Vol. 129, May 23, 1930, pages 680–683.

This paper records the results of an investigation into the properties of certain steels containing chromium up to 11.70%. It was found that silicon-chromium steels were not very strong at temperatures in excess of 700° C. Silicon decreases the hardening properties. An increase of this element to 3½% makes the steel more brittle in the cold and decreases the strength at elevated temperatures. A suitably heat-treated steel containing 8% chromium with 3½% silicon is stronger and more ductile at room temperatures than one with less chromium or silicon, but it is weaker at elevated temperatures. Increasing the silicon causes a decrease in hardening properties and there is a lack of ductility at 900° C. in steels containing between 1.0 and 1.5% silicon. The steels containing 3% silicon do not show this phenomenon. The nickel-chromium austenitic steels possess better static properties at elevated temperatures than the silicon steels. They are stronger and do not appear to be so plastic when hot. From the results obtained it would appear that there is little to be gained by increasing the nickel and chromium content from 9% – 12 or 13%. The elongation and reduction of area of the nickel-chromium steels at various temperatures are fairly constant, whereas in the case of the silicon-chromium steels the values of these particular properties increase with increasing temperatures of testing. This is very evident at 800° C.; the nickel-chromium steel has a reasonable reduction of area, whereas the silicon-chromium steel pulls out almost to a point. A table is given showing the properties at elevated temperatures of the steels examined. LM&AEH(3)

**The Physical Properties of Copper Alloy Steels, with Special Reference to Heat Treatment. (Ueber die Mechanischen Eigenschaften kupferlegierter Stähle unter besonderer Berücksichtigung der Wärmebehandlung.)** F. NEHL. (Vereinigte Stahlwerke A.G., Stahl und Walzwerke Thyssen, Mülheim-Ruhr.) *Stahl und Eisen*, Vol. 50, May 15, 1930, pages 678–686.

Paper before the Annual Meeting of the Verein deutscher Eisenhüttenleute, May 17, 1930. The author examined the physical properties of a great variety of copper bearing steels and found that copper steels offer the following advantages over non-copper steels: a higher resistance to corrosion, a higher value for the relation yield point to tensile strength, a higher hot tensile strength and the property of age hardening. The table gives some results in testing sheets, 10, 15 and 20 mm. thick, of the following composition: C 0.12%, Mn 0.65%, P 0.011%, S 0.03%, Si 0.16%, Cu 0.85%.

**Table No. 1**

| Sheet Thickness mm. | Tensile Strength Lbs./in.² | Yield Point Lbs./in.² | Relation Yield Point to Tensile Strength in % | Elongation % | Notch Toughness Mkg/cm² |
|---|---|---|---|---|---|
| | highest value 69,800 | 47,500 | 68 | 25.0 | 25.1 |
| 10 | lowest value 67,200 | 45,100 | 67 | 22.0 | 12.1 |
| | highest value 67,600 | 45,500 | 67 | 27.0 | 21.2 |
| 15 | lowest value 65,000 | 43,100 | 66 | 25.5 | 15.0 |
| | highest value 67,200 | 45,000 | 67 | 27.0 | 22.3 |
| 20 | lowest value 64,400 | 42,800 | 67 | 24.0 | 15.5 |

Table No. 2 gives comparative results in testing the physical properties of non-copper and copper steel-sheets (20 mm. thick) at higher temperature Steel A (carbon steel) contains C 0.29%, Si traces, Mn 0.60%, P 0.026% S 0.036%, Cu 0.14%; steel B (copper steel) contains; C 0.11%, Si 0.16% Mn 0.65%, P 0.011%, S 0.036%, Cu 0.85%.

The aging hardness of copper steels which results in an essential improvement was studied in detail. In aging the mentioned steel at temperatures between 500 and 550° C. the following properties were found:

| | Tensile Strength Lbs./in.² | Yield Point Lbs./in.² | Elongation % | Notch Toughness Mkg./cm.² |
|---|---|---|---|---|
| As delivered | 65,500 | 43,500 | 25.0 | 17.5 |
| Aged | 83,600 | 62,200 | 15.5 | 7.2 |

This corresponds to an increase of tensile strength by 28%, yield point by 45%, a decrease of elongation by 32% and notch touchness by 58%. From further investigations on the age hardening of copper steels the following conclusions are drawn: (1) Steels with a copper content of more than 0.60% can be improved by aging unless the cooling rate is too slow. (2) The highest effect of aging is obtained in aging for 4–8 hours at 450 – 500° C. An aging time from 1–3 hours is sufficient in aging at 500 – 550° C., but the increase of the properties is not as noticeable as when the aging takes place at 450–500° C. (3) No change of physical properties was found in aging below 390° C. The possibility of using copper steels for construction materials, for boiler construction and for certain forged materials is pointed out. GN(3)

## CORROSION, EROSION, OXIDATION, PASSIVITY & PROTECTION OF METALS & ALLOYS (4)

**Nickel and Copper Cast Irons. (Recherches sur quelques fontes au nickel et au cuivre.)** M. BALLY. *Revue du Nickel*, Vol. 1, Oct. 1929, pages 16–18.

See *Metals & Alloys*, Feb. 1930, page 384. (4)

**Turbine Blade Corrosion.** *Engineer*, Vol. 149, Feb. 14, 1930, page 193.

From article in "Vulcan," the journal of the Vulcan Boiler and General Insurance Company, Ltd. Describes corrosion of blading of impulse turbine having seven stages. First three rows of blading which were of Ni steel were badly corroded. Corrosive action seemed to have been intermittent because blading was reported to have been in good condition at end of first 18 months' work. Conclusion was that some foreign matter had been carried over with steam from boiler. LM(4)

**The Corrosion of Lead.** *Engineering*, Vol. 129, April 11, 1930, page 494.

Pb is extremely resistant to corrosion but it has been known to fail particularly when in contact with cement, mortar, timber or soil. Study being made by the Building Research Station includes a review of the literature, a study of the conditions under which corrosion occurs and the means for its prevention. Discusses protective coatings. LM(4)

**Nickel-Chromium Heat Resisting Alloys.** *Nickel Bulletin*, Vol. 3, Jan. 1930, pages 5–9.

Gives various applications of chromite in the glass industry, power plants and annealing pots.

**Red Water Trouble and the Remedy at West Palm Beach.** L. O. WILLIAMS (West Palm Beach Water Company). *Journal American Water Works Association*, Vol. 22, June 1930, pages 791–795.

The new plant of the West Palm Beach Water Co. was officially put in service January 1, 1927. The raw water is taken from Clear Lake and Lake Mangonia which are filled strictly by surface drainage, and consequently has a high color. This requires a high alum dosage. The water delivered had a pH between 6.2 and 6.8 with an oxygen content of 9 p. p. m. and a carbon dioxide content between 2 and 6 p. p. m. Trouble with red water was encountered. Lime was added (0.71 grains per gallon) to give a pH of 9.4. This pH was at the point of precipitation of calcium carbonate. Upon examination it was found that a slight coating had formed. When the pH dropped to 8.3, which was below the equilibrium point and gave a slight excess of carbon dioxide, red water returned. The water is now being furnished at about pH 9.2. (4)

**Corrosion by Superheated Steam.** J. K. RUMMEL. *Iron Age*, Vol. 124, Dec. 5, 1929, pages 1525–1527.

During the years 1926–1929 the service department of the Babcock & Wilcox Company has investigated boiler units working under varying conditions, with a view to determining the reaction between iron and steam at elevated temperatures. In the case of a 3-pass radiant heat superheater the last pass was equipped with "Enduro K. A. 2" tubes (nickel 8, chromium 18%); the use of this material considerably lessens the corrosion occurring under high-pressure steam conditions and allows of the use of higher temperatures than those permissible with tubes of iron or unalloyed steel. (4)

**Corrosion of Carburized and Nitrided Steels. (La corrosion des aciers cémentés ou nitrurés.)** L. GUILLET & M. BALLAY. *Comptes Rendus*, Vol. 189, Dec. 2, 1929, pages 961–963.

A study of the comparative corrosion resistance of a series of nickel, nickel-chromium and nickel-chromium-molybdenum steels when heat treated and then carburized or nitrided. The corrosion media considered were: 5% sulphuric acid (24 hours), 5% hydrochloric acid ( 9 days), salt water plus 5% hydrogen peroxide (16 days), brine spray of 20% NaCl (18 days), 10% copper sulphate (43 hours) and water from the River Seine, Paris, (60 days). Results tabulated. (4)

**Technical Testing of Rust Protecting Paints. (Beitrag zur technischen Prüfung von Rostschutzfarben.)** FRIEDRICH HÖPKE. *Deutscher Verband für die Materialprüfungen der Technik*, No. 79, Nov. 1929, 40 pages.

This report shows that with the aid of certain tests it is possible to obtain satisfactory and reproducible results. These tests are considered in detail and the author points out the necessity of additional work along this line in order to set up uniform methods. (4)

**The Passivity of Metals. III. The Quantity and Distribution of the Superficial Oxide.** U. R. EVANS & J. STOCKDALE. *Journal Chemical Society*, Nov. 1929, pages 2651–2660; *Chemical News*, Vol. 139, Dec. 13, 1929, page 379.

A new method is described for the removal of the surface skins of metals to preserve the metal enclosed in the layer of oxide. Films have been removed from nickel, carbon steel and other metals and a transparent skin from Staybrite Steel. (4)

**Alloy Additions Affect Corrosion of Cast Iron.** PAUL KOETZSCHKE. *Foundry*, Oct. 15, 1929, Vol. 57, pages 863–866.

Results show that silicon plays an important part in rust and corrosion resistance of cast iron. 1.5–3.0% of silicon does not have any influence on the rate of corrosion in hydrochloric acid. Nickel addition up to 6% reduces corrosion in hydrochloric acid about 20–25%. While in acetic acid even slight increase in acid increases intensity of attack. Chromium has a beneficial effect but increases machining difficulties. Silicon is attacked strongly in strong alkalis. By addition of nickel the attack is diminished. Gives also results of atmospheric corrosion, in which an addition of from 0.3–0.4% of copper reduces corrosion about 25%. VSP(4)

**Zinc as a Protective Coating Against Corrosion Fatigue of Steel.** WILBER E. HARVEY. *Metals & Alloys*, April 1930, Vol. 1, pages 458–461.

Corrosion-fatigue value or limit is the highest stress which a metal will endure for 10,000,000 cycles when subjected to repeated stresses and exposed simultaneously to the corrosive influence of a stream of water. There is no relation between this limit and the mechanical properties, chemical composition, heat treatment and any previous cold working of the metal. The corrosion fatigue limit is related only to the electrolytic solution pressure of the metal for that particular corroding medium. The electrolytic solution pressure is increased probably in the proportion that the stress has been raised. Data presented show that zinc surface as sherardized, galvanized and electroplated coatings prevents any of the water from reaching the surface of the underlying steel and that the effects of corrosion are entirely eliminated. The electroplated specimens in water are shown to have the same fatigue limit as the uncoated specimens in air. Hard brittle intermetallic compounds occur with galvanized sherardized coatings which causes premature failure. Suitably coated the fatigue limit of a metal in water will like the endurance limit in air range from 40–50% of the tensile strength. ESC(4)

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**Table No. 2**

| Property | Testing Temperature 20° C. A | 20° C. B | 100° C. A | 100° C. B | 200° C. A | 200° C. B | 300° C. A | 300° C. B | 400° C. A | 400° C. B | 500° C. A | 500° C. B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yield point, lbs./in.² | 32,200 | 47,500 | 31,200 | 42,900 | 31,800 | 42,100 | 23,900 | 34,200 | 24,400 | 31,500 | 13,600 | 25,600 |
| Tensile Strength, lbs./in.² | 67,500 | 67,400 | 62,800 | 66,100 | 75,000 | 81,000 | 72,800 | 77,500 | 54,500 | 61,500 | 33,700 | 42,000 |
| Relation Y. P. to T. S., % | 47.6 | 70.3 | 49.7 | 65.0 | 42.3 | 51.8 | 32.9 | 43.5 | 44.7 | 51.0 | 40.3 | 61.2 |
| Elongation, % | 20.7 | 26.0 | 15.5 | 18.3 | 12.4 | 17.2 | 22.4 | 22.5 | 21.6 | 28.5 | 26.4 | 26.7 |
| Reduction of area, % | 55.7 | 61.0 | 54.0 | 45.5 | 39.6 | 42.3 | 48.0 | 40.6 | 59.9 | 52.5 | 72.0 | 48.2 |

**Aluminum Alloys Which Resist Sea Water Corrosion.** *American Metal Market*, May 6, 1930, Vol. 37, page 10.

Results of tests on the corrosion resistance of aluminum alloys to seawater and published in *Metallboerse* for Feb. 15, 1930, show that an alloy of 88% Al, 10% Zn and 2% Cu, very satisfactorily resists corrosion alone but corrodes badly when in contact with brass or bronze. The most resistant alloy contained 3% Mg, 3% Mn, 0.93% Sb, 0.56% Fe., 0.26% Si, with traces of Zn and Pb, and the remainder Al. WHB(4)

**Electric Furnace and Alloy Cast Irons for Corrosion Resistance.** E. VALENTA. *Iron Age*, Feb. 13, 1930, Vol. 125, page 532.

Abstract of paper presented at the Oct. Congress of Foundrymen at Paris. Recommends electric furnace cast iron as having great tensile, compressive and bending strength, and high resistance to impact and fatigue. Such cast iron maintains its good qualities at temperatures up to 450° C. Austenitic cast iron (alloys with 14–15% nickel and 5 to 6% copper) show greatest resistance to corrosion. VSP(4)

**Corrosion and Its Prevention in the Oil Industry.** H. W. GILLETT. *Metals & Alloys*, Feb. 1930, Vol. 1, pages 379–380.

A correlated abstract covering papers delivered at the Chicago Meeting of the American Petroleum Institute, December 4 and 5, 1929. ESC(4)

**On the So-Called White Rust on Galvanized Iron Materials. (Ueber de nsogenannten weissen Rost auf verzinkten Eisenwaren.)** E. H. SCHULZ. *Stahl und Eisen*, March 20, 1930, Vol. 50, pages 360–362.

Report No. 161 to the Materials Committee of the Verein deutscher Eisenhüttenleute. The so-called white zinc rust is composed of $H_2O$, $CO_2$ and ZnO and is to be attributed to unfavorable storage conditions. Sufficient ventilation of warehouses avoids the formation of condensed water and consequently the formation of white zinc rust. The purity of the zinc coating has no influence. This white zinc rust is absolutely different from white sediments of similar appearance but different composition, originating in seawater. GN(4)

**Corrosion Tests with Aluminum and Duralumin in Sea Water. (Korrosionsversuche mit Aluminium und Duralumin in Meerwasser.)** *Zeitschrift für Metallkunde*, November 1929, Vol. 21, pages 378–386.

An exhaustive investigation was carried out by the Corrosion Committee of the *Deutsche Gesellschaft für Metallkunde* with Al and Duralumin sheets in the North and Baltic Seas having the following composition:

| North Sea | | | Baltic Sea | |
|---|---|---|---|---|
| NaCl | 2.558% | | 1.538% | |
| KCl | | | 0.052% | |
| $MgCl_2$ | 0.257% | | 0.195% | |
| $MgSO_4$ | 0.100% | 3.155% | 0.114% | 2.000% |
| $MgCO_3$ | 0.020% | | 0.015% | |
| $CaSO_4$ | 0.220% | | 0.091% | |

The Al sheets were hot rolled at 300–400° C. and the Duralumin employed contained: 4% Cu, 0.5% Mg, 0.25% Mn. Time of experiments: 10 months. The sheets were partly covered by (*a*) a chromate coating according to Bauer-Vogel, (*b*) an electrolytic coating according to Günther-Schulze, (*c*) a sprayed lead coating. The main results of the numerous tests are summarized as follows in the abbreviated report: Due to its larger tendency to local corrosion, duralumin is less stable in sea water than pure aluminum, but it is possible to improve the corrosion resistance to sea water by carefully heat-treating the duralumin. None of the coatings tested proved to be a complete protection against corrosion which occurs under the coating in the same fundamental manner but only at a slower rate. Accidental surface injuries are of considerable influence. Sprayed lead coating proved to be the poorest one. Chromate and electrolytic coating represent a good protection for pure Al. Welding resulted in a favorable influence on corrosion stability in pure Al in contrast with duralumin if not subsequently heat-treated. Riveting which does not exert a detrimental influence on the corrosion resistance should be accomplished with a metal which has a small difference in potential with the plate. Less noble rivets protect the sheets from attack, it is true, but are readily attacked themselves. A more pronounced corrosion attack occurred near the surface of the sea than at greater depths. A chipping off of the coatings during bending test did not take place. No definite statement is given in regard to the two different corroding media. EF(4)

**Protection of Electron Metal against Corrosion. (Korrasionsschutz bei Electronmetall.)** KARL HIEGE. *Metallwirtschaft*, April 25, 1930, Vol. 19, pages 361–362.

Magnesium and its alloy, Electron metal, form a coating of oxide on the surface when exposed to moist air similar to Fe, Al and Zn. In contrast to Fe the oxide turns to carbonate which protects it against further corrosion. Electron is not attacked by NaOH, KOH, soap solution and $NH_4OH$. Al is slightly soluble in $NH_4OH$. Electron can be used for pistons for $NH_3$ compressors. It is not attacked by pure HF, KF, NaF, $NH_4F$, alkaline and neutral organic compounds such as lacquer solvents, neutral fats, mineral oils, benzine and benzol. It is attacked by $H_2SO_4$, HCl, $HNO_3$, acetic, lactic and fruit acids, chlorides, sulphates and nitrates. When alloyed with Mn it is more resistant against atmosphere and salt solutions and is used for water pipes. To obtain further protection Electron can be lacquered. The surface must first be roughened by etching in solution of 18 kg. $K_2Cr_2O_7$ in 100 liters of 20–21% $HNO_3$ for 1/2–2 minutes and rinsing. White lead oil paint, which is used for duralumin, attacks Mg. For aircraft work Ti white gives good results and stands up well in the salt spray test. Oil varnishes give good protection, but are slow drying. Nitrocellulose lacquers are better against water and dry faster, but it is necessary to clean thoroughly from grease and oil before applying. Bakelite varnishes are good. They must be baked and not applied too thick to prevent brittleness. CEM(4)

**Acid Resisting Steels.** W. H. HATFIELD. *Metallurgia*, Vol. 1, Nov. 1929, pages 17–20, 26.

Study on the comparative corrosion resistance to nitric acid, phosphoric acid, sulphuric acid and hydrochloric acid of various concentrations at 20° C. of ordinary mild steel, 14% chromium steel, 12% Cr and 12% Ni steel, 15% Cr and 11% Ni steel, 18% Cr and 8% Ni steel. Results tabulated. (4)

**Deterioration of Structures in Sea Water.** *Engineering*, Vol. 129, April 25, 1930, pages 544–545.

From Tenth (Interim) Report of the Committee of the Institution of Civil Engineers for 1928–29 edited by John Purser and H. J. Grose. Bars of 13.57% Cr steel after heating to 650° C., air cooling and grinding free from scale, and polishing were embedded in concrete at both ends and exposed for 5 yrs. at Plymouth under various conditions. Bar exposed above high water was in perfect condition, one submerged continuously in fresh water was stained on surface and slightly rusted, those exposed at half tide level and completely submerged were attacked locally although they retained much of their original polish. Other tests were made to determine whether metals were weakened by exposure otherwise than through loss of material. Sir Robert Hadfield who made report concluded that weakening of material due to corrosion is direct result of loss of material. Tests were made on various protective coatings. Results showed that iron oxide paint applied with raw linseed oil was better preservative than red lead. Preliminary report is made on tarred steel plates after 17 months' exposure at half tide level. LM(4)

**Reproducibility in Corrosion Work.** ULICK R. EVANS. (Cambridge University, England.) *Preprint* 57-7, *American Electrochemical Society*, May 29–31, 1930, pages 61–71.

Lack of agreement between 2 "identical" corrosion experiments may be due (1) to experimental causes, such as non-uniformity of material, surface condition, or physical conditions, especially those affecting the oxygen supply, (2) to fundamental causes, which can be discussed from the probability standpoint. Corrosion usually starts from independent points, believed to be weak places on an invisible oxide-film, and where the number of these points on each specimen is small, considerable variation from the mean is to be expected. There is, however, evidence that each breakdown gives protection to the surrounding territory, thus decreasing the probability of other breakdowns, and this automatically makes the reproducibility better than would be calculated from Poisson's formula. (4)

**The Corrosion of Metals.** ULICK R. EVANS. *Engineering*, Vol. 129, Jan. 31, 1930, page 134.

Letter commenting on statement in *Proceedings of the Institution of Mechanical Engineers*, 1929, I, page 545, concerning effect of minor constituents on corrosion of iron and zinc. Writer refers to work of other investigators showing that pure zinc and iron are not entirely immune from corrosion. Gives footnote references. LM(4)

**On Corona on Aluminium Conductors as Affected by Corrosion due to Atmospheric Exposure.** E. WILSON. *Transactions Faraday Society*, Vol. 25, Sept. 1929, pages 496–502.

In continuation of a research on the effects of corrosion on the electrical conductivity and mechanical properties of high purity aluminum and light aluminum alloys, determinations have been made of the stability of aluminum conductors, with special reference to the critical voltage at which corona begins to develop. This paper deals with these properties as observed in very pure aluminum, and in nickel-aluminum alloys containing 0.75–2.31% of nickel. Samples of these alloys, in the form of 0.126″ wire, were exposed for 24 years on the roof of King's College, London, and determinations of physical and mechanical properties of the wires after this period indicated that, due to their high resistance to atmospheric corrosion, the nickel-aluminum wire is very definitely superior to pure aluminum. Corrosion of the aluminum wire had increased the resistivity to a marked degree, and the corona discharge had also become much greater as a result of the roughening of the surface; both of these undesirable changes are absent in the nickel-aluminum alloy specimens. (4)

## STRUCTURE OF METALS & ALLOYS (5)

### Metallography & Macrography (5a)

**The Status of the Double Iron Carbon Diagram.** A. I. KRYNITSKY. *Metals & Alloys*, April 1930, Vol. 1, pages 465–469.

A correlated abstract. The literature on this question is thoroughly analyzed and an extensive bibliography is appended. ESC(5a)

**A Study of the Rate of Grain Growth in Low Carbon Steel.** H. E. PUBLOW & S. E. SINCLAIR. *Bulletin* No. 29, *Michigan Engineering Experiment Station*, East Lansing, Michigan, April 1930, 20 pages.

It was found that at all temperatures from 1600–1900° F., the same grain size will be reached, the only variable being the length of time the steel is maintained at the temperature desired. The same result is obtained in 15 minutes at 1900° F. as is obtained in 36 hours at 1600° F. The best fine grained structure is obtained from coarse grained stock, by holding it at a temperature slightly above the $Ac_3$ point for only sufficient time to be sure the piece is uniform throughout. The hardness did not vary with the grain size. HWG(5a)

**Some Observations on the System Iron–Nitrogen.** ROBERT F. MEHL & CHARLES S. BARRETT. *Metals & Alloys*, March 1930, Vol. 1, pages 422–423.

A correlated abstract. A discussion of the available data on the iron-nitrogen system with particular reference to the evidence of compounds formed. The author concludes on the basis of microscopic, X-ray and spectrographic data presented that the iron-nitrogen compound richest in iron may have only 1/2 or 1/3 the number of iron atoms other investigators believe to be present. ESC(5a)

**Dilatometric Experiments of the Thermic Effect when Tempering Duralumin and Its Structural Constituents. (Dilatometrische Untersuchungen der Thermischen Effekte beim Anlassen von Duralumin und seine Aufbaukomponente.)** M. HAAS & H. HECKER. *Zeitschrift für Metallkunde*, May 1929, Vol. 21, pages 166–173.

See full translation in *Metals & Alloys*, September, 1929, pages 124–131. EF(5a)

**The Solidus of the Iron-Carbon System.** O. W. ELLIS. *Metals & Alloys*, April 1930, Vol. 1, pages 462–464.

The values of the liquidus of the iron-carbon alloys as obtained by Carpenter and Keeling in 1904 are compared with those of Andrew and Binnie of 1929. Assuming a straight line for these values—Raoults Law—equations derived from these observations when extrapolated to the melting point of iron yield 1508° C. for the values of Carpenter and Keeling and 1537° C. for those of Andrew and Binnie. The values of the latter are not so nearly in line due to the use of commercial steels. Equations may be considered as absolutely parallel. A correction of 292° C. applied to the earlier observations would bring them in line with the later results. A plot of these values, the first corrected and the latter as observed together with later values of Joming, Ellis, and Kaya indicates clearly a discrepancy between two schools of observations which cannot be explained but encourage more accurate observation which is recommended by the author. ESC(5a)

**The Effect of Annealing upon the Solidus Temperature of Alloys.** J. H. ANDREW & H. M'NEIL. *Journal Royal Technical College*, Vol. 2, Jan. 1929, pages 64–72.

The wide temperature range between the liquidus and the solidus of certain alloy solid solutions are discussed. Experiments carried out with a copper-tin alloy giving normally a range of 150° C. have proved that this range can be reduced very considerably by annealing. The question of grain refinement has been dealt with and a new hypothesis put forward to explain the fact that refinement is never produced by cooling through but only by heating through a transformation. (5a)

**Phases of the Metastable Iron-Carbon Diagram.** R. L. DOWDELL *Metals & Alloys*, Vol. 1, May 1930, pages 515–519.

A correlated abstract. A detailed discussion of the literature regarding the metastable iron-carbon diagram is presented. A complete bibliography is cited. ESC(5a)

**A Method of Finding the Molecular Constitution of Certain Liquid and Solid Intermetallic Solutions.** F. H. JEFFERY. (The Goldsmiths' Metallurgical Laboratory, Cambridge, England.) *Transactions Faraday Society*, Vol. 26, Feb. 1930, pages 86–89.

Calculates results giving them in table form for solutions of Sb in Pb, Pb in Sb and Cd in Sb. The liquidus and solidus for each system was determined by an electrical resistance method developed by the author. Sb dissolves in Pb as such, and also Pb in Sb. At temperatures near liquidus, molecule of each metal is monatomic. There is no evidence of intermetallic compounds. Same is true of a certain range of solutions of Cd in Sb both liquid and solid. LM(5a)

**Austenite and Its Decomposition.** ALBERT SAUVEUR. *Transactions American Society Steel Treating*, Feb. 1930, Vol. 17, pages 199–218; *Iron & Coal Trades Review*, Oct. 1929, Vol. 119, page 620.

A paper presented before the American Society for Steel Treating at Cleveland, Sept. 9–13, 1929. Attempts to show that the mechanism of the transformation of austenite remains the same whether the cooling be slow, resulting in pearlitic structure, or rapid, producing a so-called "Martensitic" structure. The transformation is brought about by an alpha phase locating itself at the grain boundaries and along some of the crystallographic planes of the mother austenite, giving rise to the Widmanstätten type of structure on slow cooling and to the martensitic type on rapid cooling. Martensite is an aggregate of supercooled austenite and of a supersaturated solution of carbon in alpha iron—the latter containing also finely divided cementite particles. The author believes this alpha constituent answers our conceptions of troostite. The recent theories advanced to explain the hardening of steel by quenching, namely the grain size, distortion and dispersion theories, are briefly outlined. Discusses the differences between the hardening of steel after rapid cooling and the hardening of some non-ferrous alloys after quenching followed by aging.
WHK & RHP(5a)

**Age Hardening Lead-Calcium Alloys.** EARLE E. SCHUMACHER & GEORGE M. BOUTON. *Metals & Alloys*, March 1930, Vol. 1, pages 405–409.

The diagram of the lead-calcium system shows 3 compounds $Pb_3Ca$, PbCa, and $PbCa_2$. Out of those in the range between Pb and PbCa which have commercial possibilities up to 2% Ca have been studied. The alloys investigated in this work disclosed definite age hardening properties. Liquidus arrests and solidus arrests for lead calcium alloys up to 1% calcium. A peritectic region at the lead end of the system is indicated by the time temperature cooling curves by a horizontal portion about 1° above the melting point of lead. This composition range has been determined by microscopic examination. Observations on the solid solubility of calcium in lead were made by conductivity determinations. The curve showing conductivities after 18 months has a break at 0.01% Ca. Hardness studies indicate that Pb– 0.04% Ca solid solution first begins to expel calcium at some temperature between 228 and 200° C. The study further shows that supersaturated solution exists between 265° C. and the above temperature. Tensile strength tests indicate age hardening of alloys containing as little as 0.01% Ca. Fatigue resistance tests show superior property of calcium lead alloys over the antimony lead compositions. Data and curves are given. The effects of double aging have been investigated.
ESC(5a)

**Centrifugally Cast Irons and Their Metallographic Investigation. (Schleuderguss und seine metallkundliche Untersuchung.)** K. L. ZEYEN. *Stahl und Eisen*, Vol. 50, May 15, 1930, pages 701–702.

Abstract of a paper by M. v. Schwarz & A. Väth in *Giesserei*, Vol. 17, (1930), pages 177–182, 204–208, 230–234, 253–259. The authors examined 63 various types of centrifugally cast irons of common phosphorous-rich cast iron with the following composition: C 2.98–3.26%, Si 1.23–5.4%, Mn 0.14–0.72%, P 0.74–1.42%, S 0.016–0.148%. The average bending strength amounted to 19.8–24.1 tons/in.$^2$ In tabulating these 63 irons in two groups with either 0.8–1.1% P or 1.2–1.4% P, it was found that in both groups the hardness decreases with increasing silicon content with the highest decrease between 2–3% Si, which is due to the prevailing ferritic ground mass. The evaluation of the observed hardness values reveals that the critical lower percentage of silicon for a good machinability amounts to 2.1% for the group 8–1.1% P and to 2.25% Si for the group 1.2–1.4% P. The specific gravity decreased in both groups with increasing silicon content. Group 2 shows the same silicon content but a lower specific gravity than group 1. Investigations of unannealed centrifugal castings, processed according to the Billaud method gave no new observations. Annealing tests resulted in a remarkable decrease of hardness only after an annealing above 500° C. Tests on segregations were finally carried on.
GN(5a)

**Alloys of Iron Research. Part IX. The Constitution of the Alloys of Iron with Silicon.** JOHN L. HAUGHTON & MAURICE L. BECKER. *Journal Iron & Steel Institute*, May 1930, *Advance Copy* 7, 18 pages; *Engineer*, Vol. 149, May 16, 1930, page 539; *Engineering*, Vol. 139, May 16, 1930, pages 653–654; *Foundry Trade Journal*, Vol. 42, May 22, 1930, page 379; *Iron & Coal Trades Review*, Vol. 120, May 9, 1930, page 759.

This paper is the ninth of the series of researches on the alloys of iron, carried out at the National Physical Laboratory. Much purer materials have been used than were previously available and every precaution taken to eliminate contamination. The constitution of the alloys of iron and silicon has been determined, and very considerable differences have been found between the present results and those of the previous observers—differences which are doubtless due in part to the purity of the materials used. The existence of phases which appear to correspond with the compounds FeSi and $Fe_3Si_2$ has been confirmed, and in addition a phase which is probably the compound $Fe_2Si_5$ has been shown to exist. LM & AEH(5a)

**Constitution of Nickel-Manganese Alloys.** N. B. PILLING & T. E. KIHLGREN. *Transactions American Society for Steel Treating*, Vol. 16. Aug. 1929, pages 326–327.

A further contribution to the Data Sheet series now in preparation by the American Society for Steel Treating and the American Institute of Mining & Metallurgical Engineers deals with the constitution of the nickel-manganese alloys. Reference is made to the early work (1908) of Zhemczhuzhny, Urasov and Rykvoskov and to the modified form of equilibrium diagram published at a later date by Dourdine. The literature on the nickel-manganese alloys is sparse, but the data available would appear to indicate that 2 series of solid solutions exist in the series (i. e., up to 38 and from 71% manganese) with an intervening heterogeneous range. (5a)

**Constitution of Nickel-Carbon Alloys.** N. B. PILLING & T. E. KIHLGREN. *Transactions American Society for Steel Treating*, Vol. 16, July 1929, pages 171–172.

A summary of information on the constitution of the nickel-carbon alloys has been prepared for the Data Sheet Committee of the American Society of Mining and Metallurgical Engineers and the Recommended Practices Committee of the American Society for Steel Treating. The equilibrium diagram given is that published by Kasé in 1925, and data are presented relative to the effect of carbon on the vapor pressure, magnetic and other physical properties of nickel. (5a)

**Modern Steels.** J. H. ANDREW. *Proceeedings, Cleveland Institution of Engineers* (1929–30) pages 102–125; *Iron & Coal Trades Review*, Vol. 120, Feb. 7, 1930, page 243.

Abstract of a paper before the Cleveland Institution of Engineers, Middlesborough, Feb. 3, 1930. The paper was entitled, "Carbon and Alloy Steels." There are two distinct transformations in iron during cooling after freezing which take place at 1403° C. and at 900° C. Between freezing and 1403° C. the iron is in the delta form, from 1403° C. to 900° C. the gamma form exists, while below 900° C. is the alpha form. Examination of space-lattice configuration shows that alpha and delta iron are identical. Elements such as nickel and manganese lower the temperature at which transfer from the gamma to alpha state takes place. Sufficient of these alloy elements will hold the gamma state down to room temperature thus producing austenitic steel. Austenitic steel though useful in many ways is quite difficult to machine. Large masses of carbon steel cannot be water quenched effectively but an alloy of both nickel and chromium can be mass hardened even by oil quenching.
RHP(5a)

**Thermal Analysis of Steel.** Proposed revised tentative recommended practice, Appendix to Report of Committee E-4 on Metallography, in *Preprint* 25, June 1930 Meeting, *American Society for Testing Materials*, 4 pages.

General outline of requirements of correct practice in the inverse rate and differential methods of thermal analysis. In the latter, temperature differences of 0.04° C. should be detectable. Checking of thermocouples may be carried out by observing the $A_2$ point of ingot iron (768° C.) for the inverse rate method, or the $Ac_1$ point of unalloyed carbon tool steel for the differential method. At a heating rate of 0.1° C. per second this point is at 733° C. There is a list of the items on which data should be recorded for a thermal analysis run and a discussion of the interpretation of the curves.
HWG(5a)

**The Nickel-Iron-Copper System.** P. R. KOSTING. *Rensselaer Polytechnic Institute, Engineering & Science Series*, No. 26, June 1930, pages 1–27.

Study was made of 33 alloys in the Ni, Fe, Cu system, deoxidized with about 0.5% Mn and usually about 0.1% each of Al and Mg. The thermal expansion, the electrical resistance and the thermo-electric properties, as well as the thermal coefficients were determined, and are shown in ternary diagrams. Fe and Cu are relatively immiscible, while Ni is miscible with both. For the following ratios of Fe to Cu, Ni in the amount given has to be present to secure complete solubility of Fe and Cu in the ternary alloy; 25 Fe : 75 Cu takes 38% Ni; 50 Fe : 50 Cu takes 40%; 75 Fe : 25 Cu takes 23%. Cu is soluble in Invar (36% Ni, 64% Fe) up to 22%. Fe is soluble in constantan (45% Ni, 55% Cu) up to 15%.
HWG(5a)

**An Investigation of the Vanadium–Carbon System.** ATOMI ÔSAWA & MASAKICHI ÔYA. *Science Reports Tohoku Imperial University*, Vol. 19, March 1930, pages 95–108.

The vanadium–carbon system was investigated by means of the microscopic observation and X-ray analysis, and a probable diagram was proposed. In this system there exist 3 phases $\alpha$, $\beta$ and $\epsilon$, the latter 2 corresponding to compounds $V_5C$ and $V_4C_3$ with a solubility. The crystal form of the former compound is hexagonal, having an axial ratio of 1.59 and the atomic distribution is hexagonal close-packed. The crystal form of the latter compound is a cubic, having a face-centered distribution of vanadium atoms. The $\alpha$-phase, a vanadium solid solution and $\beta$-phase, and $\beta$- and $\epsilon$-phases form eutectic respectively. (5a)

**The Composition of Eutectics.** D. STOCKDALE. *Journal Institute of Metals, Advance Copy* 526 (1930), 19 pages; *Metal Industry* (London), Vol. 36 (1930) pages 325–328, 355–356; *Engineer*, Vol. 149, Mar. 21, 1930, page 320; *Engineering*, Vol. 129, Mar. 21, 1930, pages 383–384.

This paper describes experimental work carried out to prove or disprove a theory of the author who states he has long believed that in a binary eutectic the atoms of the two elements are present in a simple ratio. The experiments failed to decide this point, and the justification of the paper is due to the intrinsic interest of the experiments themselves. The following eutectic systems were examined: aluminum–copper, antimony–silver, cadmium–tin, copper–silver and lead tin. A description of a sensitive apparatus for the measurement of cooling curves is given and a new method for the determination of the liquidus from such curves is outlined. An attempt was made to carry out the experiments, in vacuo without success. The lead-tin alloys were examined under nitrogen and under hydrogen and identical results obtained in each case.
LM & AEH(5a)

**The Diffusion of Zinc in Copper Crystals.** C. F. ELAM. *Journal Institute of Metals, Advance Copy* 518, 1930, 15 pages; *Engineer*, Vol. 149, Mar. 28, 1930, page 346; *Engineering*, Vol. 129, Mar. 28, 1930, page 398.

A description is given of experiments made to determine whether zinc would diffuse into copper crystals. Diffusion was found to take place only to a very limited extent at high temperatures, and the conclusion drawn was that the vapor pressure of the zinc was a very important factor, although not the only factor, in determining this diffusion. Experiments were also carried out with brass crystals of various compositions, and it was found that when a $\beta$-brass crystal was heated in zinc vapor a layer of $\gamma$ was deposited which was also a crystal. The relationship between the two crystals was found to be sometimes parallel growth and sometimes a twin. Experiments were also made to determine the extent in which zinc could be diffused out of a brass crystal by heating, in vacuo. AEH & LM(5a)

**Macrostructure of Cast Alloys: Effect of Turbulence due to Gases.** R. GENDERS. *Journal Institute of Metals, Advance Copy* 519 (1930), 6 pages; *Engineering*, Vol. 129, Mar. 14, 1930, pages 357–358.

This paper is a brief addition to the authors prior paper published in the *Journal Institute of Metals*, Vol. 35 (1926), page 259, and gives some observations indicating that with small ingots cast in prepared molds the macrostructure is considerably modified through gases evolved between the mold and the liquid metal. The mold dressing used volatilized rapidly during pouring and the gas produced was found to cause turbulence as it issued through the metal. As this effect is largely dependent on the time needed for volatilization the influence on the structure varies according to the relation between the period of volatilization and the time taken by the ingot section to cool to the freezing point of the alloy. The effect is therefore, dependent upon the properties and thickness of the mold coating, and such factors as casting temperature, rate of pouring and ingot size. Increasing the size of the ingots will naturally decrease the effect due to the mold coating.
AEH(5a)

## Structure & X-ray Analysis (5b)

**X-Ray Studies of Cupped Copper.** *Engineering*, Vol. 129, Jan. 10, 1930, page 61.

Case of cups showing ears at some points of their edges was discussed before a meeting of the American Society for Testing Materials by Arthur Phillips and Gerald Edmunds. See *Metals & Alloys*, Vol. 1, Dec. 1929, page 287.
LM(5b)

**X-Rays in Engineering.** V. E. PULLIN. *Engineer*, Vol. 149, Feb. 21, 1930, pages 204–207; *Iron Age*, Vol. 125, Apr. 3, 1930, page 1007; *Proceedings Institution British Foundrymen.*, Vol. 22 (1929) pages 600–606.

Explains possibilities of radiography, defining its limits from an engineering viewpoint, describes roughly the apparatus and its use, and gives methods of the engineering radiologist. Discusses briefly some mistaken ideas regarding interpretation of radiographs. At present time 3 in. of steel is maximum thickness that can be dealt with in practice although in the laboratory it is possible to penetrate over 5 in. Gives chart for calculating exposure. Largest area which can conveniently be radiographed at one exposure is 12 in. × 12 in. Discusses deleterious effects of scattered radiation and secondary radiation giving methods for their elimination. Gives methods of dealing with irregularly shaped articles and small irregularly shaped articles in which thickness of metal varies. In thick specimens of iron or steel a flaw with dimensions of 3% of the total thickness of the part will show clearly, and in thinner specimens, up to 1/2 in. of steel very minute cracks and flaws are capable of being shown. Gives photographs of portable equipment suitable for large scale work such as examination of large airships. Gives illustrations of radiographs showing internal flaws and cracks.
VSP & LM(5b)

**Testing Materials by Means of X-Rays in the Foundry. (Werkstoffprüfung mit Röntgenstrahlen in der Giessereipraxis.)** F. WEVER. *Stahl und Eisen*, April 3, 1930, Vol. 50, pages 447–448.

The article considers the physical and technical principles of X-ray testing, the practical application for testing foundry materials and the economy of X-ray testing for a purpose under consideration.
GN(5b)

**X-Ray Determinination of the Limits of Solid Solubility in Silver Copper Alloys. (Ueber die röntgenographische Bestimmung der Mischkristallbildung von Silber-Kupferlegierungen.)** O. Weinbaum. *Zeitschrift für Metallkunde*, Dec. 1929, Vol. 21, pages 397–405.

After describing in detail the Debye Apparatus used, the preparation of the samples and preliminary tests, the author evaluates his data by modified formulae. Measurement of hardness was made for checking the results obtained by the X-ray method which gave the following summary: (1) The lattice constant ($a_0$) of Cu is increased on the Cu-side up to 3% Ag (from 3.605 to 3.622 A. U.) whereafter it remains constant. (2) The value of the lattice constant depends on the recrystallization temperature. The higher this temperature the greater is the increase of the lattice constant. (3) Tensile strength and hardness increase on the Cu-side up to 3% Ag after which concentration they remain constant. (4) The lattice constant ($a_0$) of Ag decreases up to 5% Cu on the Ag-side (from 4.078 to 4.048 A. U.) and remains constant above 5% Cu. (5) Tensile strength and hardness increase on the Ag-side up to 5% Cu and do not change appreciably beyond this concentration. (6) Recrystallization accelerated the diffusion process. (7) With short tempering times an age-hardening of Cu by Ag additions was observed whereas a marked loss in hardness after more extended tempering times was noticed. EF(5b)

**X-Ray Differentiation Between Mechanical and Galvanic Gold Plating. (Ueber die röntgenographische Unterscheidung zwischen mechanisch und galvanisch hergestellten Goldüberzügen.)** U. Dehlinger & R. Glocker. *Zeitschrift für Metallkunde*, Oct. 1929, Vol. 21, pages 325–326.

The work reported on in this paper gives the successful application of X-rays for the study of the nature of platings. According to German laws electrolytically prepared gold plate must be distinguished from mechanically prepared gold plate, designated as "doublé." A typical structure due to rolling causing a distortion of the face centered cubic lattice was observed in the X-ray photograms whereas a random orientation of the crystals was found in the electrolytically plated objects. Exceptional cases and difficulties encountered in some X-ray photograms are considered as well as the influence of various treatments after plating. EF(5b)

**X-Ray Analyses of the Nickel–Bismuth System. (Röntgenanalyse des Systems Nickel-Wismuth.)** Gunnar Hägg & Gösta Funke. *Zeitschrift für Physikalische Chemie*, Jan. 1930, pages 272–283.

X-ray and microscopic analyses of the Nickel–Bismuth system have shown the existence of two intermediary phases. The interferences of the nickel and bismuth phases always show the same position as for the pure metals. The mutual solubility must therefore be small. The intermediary phase richest in nickel (beta) possesses nickel arsenide structure. Its region of homogeneity is rather long and lies below 50 atomic percent bismuth, probably between 40 and 50 atomic percent. An equal number of nickel and bismuth atoms form a space lattice structure of the nickel arsenide type, while the surplus of nickel atoms are distributed in the interstices of this space lattice. This explains the fact that the elementary dimensions are greater with a smaller bismuth content than with a higher. The second intermediary phase (gamma) crystallizes in soft needles of hexagonal cross-section. Their region of homogeneity is narrow and lies probably near the combination $NiBi_3$. AJM(5b)

## PHYSICAL, MECHANICAL & MAGNETIC TESTING (6)

**Failure of Steel Castings and Forgings.** Robert A. MacGregor. *Iron & Coal Trades Review*, Vol. 120, Feb. 7, 1930, page 249.

Abstract of a paper entitled "The Failure of Steel Castings and Forgings through Fatigue" and presented before the North-East Coast Institution of Engineers and Shipbuilders, at Newcastle-upon-Tyne, Jan. 24, 1930. Stresses of only a fraction of the tensile strength may reach the fatigue limit. If this stress is unusual the breakdown may not occur for months after the fatigue crack has been started. If the stress is too great at frequent intervals the break may occur soon. Once fatigue has started there is no remedy. RHP(6)

**Hardness Determinations on Magnesium Alloys.** L. B. Grand & A. W. Winston. *Metals & Alloys*, Vol. 1, May 1930, page 514.

Rockwell-Brinell-Scleroscope relationships for magnesium alloys are given together with a discussion of the technique and comparative merit of these instruments. ESC(6)

**A Study of the Ikeda Short-Time Resistance Test for Fatigue.** H. W. Gillett. *Metals & Alloys*, Vol. 1, May 1930, page 520.

A critical abstract. ESC(6)

**Grinding Test Specimens Reduce Cost and Improve Product.** *Grits & Grinds*, Vol. 21, May 1930, pages 10–12.

The cost of producing fatigue testing specimens by former methods was $10 per piece, grinding in a precision machine reduced the cost to $1.80. (6)

**Tests on Belleville Springs by the Ordnance Department, U. S. Army.** D. A. Gurney. *A. S. M. E. Transactions, Applied Mechanics*, Vol. 51, No. 10, Jan.-Apr. 1929, pages 13–17 & 17–18.

Description of tests of Belleville disk-shaped springs to secure information regarding design for larger springs of this type; formula developed; history of Belleville springs; chrome-vanadium sheet steel S.A.E. 6145 tested; conclusions reached after correlation of results of tests, of mathematical analysis and of photoelastic analysis. (6)

**Tensile Tests on Rods and Wires of the Same Iron.** J. Muir. *Journal Royal Technical College*, Vol. 2, Jan. 1929, pages 5–11.

In this paper the elastic properties of rods and wires of the same iron are compared; and attention is drawn to a large increase observed in yield point extension without any corresponding change in yield point stress. (6)

**Atmospheric Action in Relation to Fatigue in Lead.** Bernhard P Haigh & Brinley Jones. *Journal Institute of Metals*, Advance Copy 521 (1930), 11 pages; *Engineering*, Vol. 129, Mar. 28, 1930, pages 399–400, 423–425; *Engineer*, Vol. 149, April 4, 1930, page 383.

The question of fatigue in lead has been examined in some detail and a number of tests carried out under abnormal conditions especially devised to ascertain the effect of air on fatigue in lead. It is believed that this is due to combined chemical and mechanical action. It was found that an oil bath, or even a water bath, round the test piece retards this fatigue and that a bath of acetic acid eliminates it entirely although a thin film of the same acid does not have the same effect. Fatigue fractures of lead are intercrystalline round the edge of the fracture only and the interior surface of the fracture is quite different from this zone. The conclusion is drawn that oxygen diffuses through lead subject to cyclic stress, and when it occurs below the surface, fatigue cracking is produced through chemical and mechanical action conjointly. LM + AEH(6)

**Tension and Torsion Tests.** R. Worthington. *Metals & Alloys*, Vol. 1, May 1930, page 513.

Data obtained from a series of tension and torsion tests on a complex copper-zinc alloy, a silicon managanese bronze and a nickel copper alloy are presented. The silicon manganese bronze has a definitely higher ultimate strength in tension than the nickel copper alloy but on the other hand just as definitely lower proportional limit and yield point. Here ultimate strength is an incorrect index of the elastic strength. In many applications—springs, marine propeller shafting, etc., the latter is a more significant property. It is shown that different metals cannot be compared by the relation between ultimate strength and proportional limit. ESC(6)

**The Magnetostriction of Various Steels.** J. S. Rankin. *Journal Royal Technical College*, Vol. 2, Jan. 1929, pages 12–19.

Paper describes a method of finding the change in length of various steels when subjected to magnetizing forces, the small changes involved being measured by oscillating thermionic valves. (6)

**The Strength of Dished Ends.** E. Hoehn. *Engineering*, Vol. 129, Feb. 14, 1930, pages 190–191.

Gives results of further investigations in answer to criticism made by E. J. Salmon of formula published by author in *Engineering*, Vol. 128, page 2. Highly theoretical giving many formulae. LM(6)

**Stress Distributions in Notched Beams and Their Application.** E. G. Coker & G. P. Coleman. *Engineer*, Vol. 149, April 25, 1930, page 453; *Engineering*, Vol. 129, April 18, 1930, page 516.

Brief abstract of paper read before the Institution of Naval Architects, April 10, 1930. Discusses importance of making notch-impact tests. LM(6)

**A Comparison of the Physical Properties of Various Kinds of Cast Iron Pipe.** F. N. Menefee & A. E. White. (Department of Engineering Research, University of Michigan.) *Journal American Water Works Association*, Vol. 22, June 1930, pages 796–836.

A series of tests on centrifugal and sand mold cast iron were run for the Water Board of the City of Detroit with the object of determining the relative service merits of 6″ and 8″ cast irons. The different tests were weighted and ratings given as in the following table. The rank of 100 in this table means that the pipe in question meets the published specifications under

| 6″ Pipe | | 8″ Pipe | |
|---|---|---|---|
| Delavaud | 110.0 | Delavaud | 110.0 |
| McWane | 108.5 | Monocast | 109.5 |
| Universal | 107.7 | Universal | 108.9 |
| American sand cast | 106.8 | French | 107.0 |
| Monocast | 105.7 | McWane | 106.7 |
| French | 104.5 | American sand cast | 105.4 |

which it is sold. The additional amounts are the points gained in the various tests. (6)

**100-Ton Testing Machine.** *Engineer*, Vol. 149, April 4, 1930, page 383.

Illustrations of this machine are given on page 380. It is an electrically operated machine of the compound lever type. It is capable of carrying out tests in tension, compression, and bending up to the full load. Specimens can be accommodated up to a stretched length of 10 ft. and wedge grips are provided to hold specimens up to 3 in. in diameter. LM(6)

**Experiments on Laminated Springs.** *Engineering*, Vol. 129, Jan. 3 1930, pages 26–29.

From Special Reports Nos. 8, 11 and 13 of the Department of Scientific and Industrial Research. Deals with displacment while running, effect of "nip" on mechanical properties, and static and endurance tests of springs made of carbon and alloy steels. LM(6)

**Problem of Deflection Measurement with Cast-Iron Bending Test. (Kritische Betrachtungen zur Frage der Bruchdurchbeigungsmessung beim Gusseisen-Biegeversuch.)** A. Thum & H. Ude. *Giesserei*, Vol. 17, Jan 31, 1930, pages 105–116.

The value of the deflection in the transverse test is dependent on the graphite size and distribution and also on the metallic matrice. The ratio $\frac{\text{transverse strength}}{\text{deflection}}$ forms a useful criterion for judging the properties and structure of cast iron. (6)

**Does Grain Size Influence the Magnetic Properties of Iron?** T. D. Yensen, *Metals & Alloys*, Vol. 1, May 1930, pages 493–495.

Electrolytic iron fused in a high frequency induction furnace and forged into ingots was machined into specimens 2.5 cm. O. D. × 1.9 cm. I. D. × 2.5 cm. long for these observations. Suitable heat treatments yielded grain sizes from 0.01 mm. to 200 mm. Values of hysteresis loss for various grain sizes are tabulated and plotted. Corroboration of these data by previous cited observations definitely demonstrates an influence of grain size upon the magnetic properties of iron. Two theories based upon these observations are presented and discussed and it is suggested that the effect will sometime be explained with greater enlightenment regarding molecular and atomic structures. ESC(6)

**Creep of Steel Under Simple and Compound Stresses.** R. W. Bailey. *Engineering*, Vol. 129, Feb. 21, 1930, pages 265–266; March 7, 1930, pages 327–329; *Engineer*, Vol. 248, Nov. 15, 1929, pages 528–529.

Condensed from paper read before Japanese sectional meeting of the World Power Conference, Tokyo, Oct. 29–Nov. 7, 1929. LM(6)

**The Effect of Tensile Overstrain on the Magnetostriction.** J. S. Rankin. *Journal Royal Technical College*, Vol. 2, Jan. 1930, pages 173–187.

It is shown that, whereas hard high-carbon steel shows less magnetostriction than soft low carbon steel, magnetostriction is greatly increased when soft low carbon steel is hardened by tensile overstrain. A theory, based on Webster's experiments on the magnetostriction of an iron crystal, on Joffe's analysis of plastic deformation, and on the results of the X-ray analysis of overstrained material, is suggested to account for the experimental results obtained. An appendix describes experiments on the magneto striction of nickel, and of 25% and 30% nickel steel. (6)

**Tests of Steel Floor Framing Encased in Concrete. Part I. Investigations of Composite Beam Action and Design of Present Test Structure.** Sidney G. Martin. **Part II. Construction, Quality of Materials, Testing and Recording.** Charles C. Whittier. **Part III. Analysis of Results and Recommendations of Committee.** Frank A. Randall. *Journal Western Society of Engineers*, Vol. 35, June 1930, pages 157–225.

Consists of a report of a special committee of the Western Society of Engineers on a series of tests of steel beams encased in concrete. Steel used for tests showed an average tensile strength of 60,400 lbs./in.² ranging from 56,000 to 63,700 lbs./in.² The average yield point of the steel was 36,200 lbs./in.² ranging from 34,400 to 37,800 lbs./in.² Gives complete laboratory reports of tests. Committee recommends that with materials of quality used in test, 24,000 lbs./in.² be used as working unit stress in designing structural steel I beams up to 24 in. in depth. American Institute of Steel Construction recommends use of working stress of 18,000 lbs./in.² although some building codes still specify 16,000 lbs./in.² Saving in weight by using 24,000 rather than 16,000 is 22.72%. Sale of structural steel in Chicago district alone amounts to 170,000 tons per yr. If half of this tonnage is used in floor construction of this nature, annual saving would be about 20,000 tons, costing erected about $1,500,000. LM(6)

**Fatigue Testing Sucker Rods to Destruction.** P. J. McCullough. *Petroleum Engineer*, Vol. 2, April 1930, pages 50–58.

A machine suitable for testing a string of sucker rods was improvised by laying two 120 foot stringers of 5 inch by 10 inch I-beams ten inches apart. A hydraulic pump was used to impart motion to a ball and socket assembly to which one end of the sucker rod is secured. Fractured surfaces of pieces broken in the fatigue testing machine show that at the beginning of fracture the grain is comparatively fine where the fracture started and progressively gets coarser as the fibre stress increases, which increase is due to the reduction in cross-sectional area of unbroken metal in the plane of fracture caused by the progress of the fracture. (6)

**The Question of Stress in the Repeated Impact Test.** (Zur Frage der Beanspruchung beim Dauerschlagversuch.) A. THUM & S. BERG. *Zeitschrift Vereins deutscher Ingenieure*, Vol. 74, Feb. 15, 1930, pages 200–204.

In the calculation of stress caused by impact, the influence of the damping capacity of the material and of the notch-effect of sharp transitions of section must be taken into account. The paper determines the impact tensions occurring in the permanent impact test and relates a few connections between impact stress and the dynamic behavior of different materials. It is shown that the application of the formulae for static conditions causes an error of almost 50%. Ha(6)

**The Relative Safety of Mild and High-Tensile Alloy Steels.** BERNARD P. HAIGH. *Automobile Engineer*, Feb. 1930, Vol. 20, pages 70–78; *Engineer*, Vol. 149, Feb. 28, 1930, pages 238–239; Mar. 3, 1930, pages 262–263; Mar. 14, 1930, pages 304–305; *Engineering*, Vol. 129, Feb. 14, 1930, pages 231–234.

This paper reviews and discusses a wide variety of tests and experiments with alternating and pulsating stresses. See *Metals & Alloys*, May 1930, page 524. RHP(6)

**A Study of the Ikeda Short-Time (Electrical Resistance) Test for Fatigue Strength of Metals.** H. F. MOORE & SEICHI KONZO. *University of Illinois Bulletin* No. 205, April 15, 1930, 31 pages.

See *Metals & Alloys*, July 1929, Vol. 1, pages 19–21; Aug. 1929, page 70. (6)

**Endurance Properties of Some Special Rail Steels.** JOHN R. FREEMAN, JR., & R. D. FRANCE. *Bureau of Standards Journal of Research*, June 1930, Vol. 4, page 851–874.

A series of tests have been carried out to determine the endurance properties of steel from heat-treated rail, medium manganese rail, a zirconium-treated medium manganese rail and a manganese molybdenum rail. Results are also given of some tests made on steel from a transverse fissured rail and an unfissured rail from the same heat that had been subjected to similar traffic. Heat treatment of rails was found to have markedly increased the endurance limit of the steel. Medium manganese rail steels were found, in general, to have a higher endurance limit than carbon rail steels. The manganese molybdenum rail steel had approximately the same endurance limit as the medium manganese rail. The steel in the fissured rail was found to have approximately the same endurance limit as steel from the unfissured rail. (6)

**Dynamic and Static Tensile Tests on Aluminum Uni-Crystals.** (Dynamische und statische Zugversuche an Aluminium-Einzelkristallen.) J. WEERTS. *Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, Verein Deutscher Ingenieure*, No. 323, 1929, 20 pages.

Since one has succeeded in producing large uni-crystals of metals the interest in their physical properties, especially their behavior to elastic and plastic deformation has become of practical importance as it elucidates many technical processes. The present contribution investigates the relation between resistance to deformation with changing velocity of deformation. The mechanical and optical testing methods and apparatus are described and the production of uni-crystals explained. The results obtained show that all plastic deformation always consists in a sliding of thin layers on octahedric planes in the direction of octahedric edges with simultaneous rotation of the crystal lattice. The results are also compared with tests with multi-crystals. Many diagrams and tables illustrate the tests. Ha(6)

**Shop Control in Manufacturing Alloy Steels.** (Die Betriebsüberwachung bei der Herstellung und Weiterverarbeitung von Edelstahl und die dadurch bedingte Betriebsforschung.) R. HOHAGE. *Stahl und Eisen*, Jan. 23, 1930, Vol. 50, pages 93–97.

Report No. 159 of the Material Committee of the Verein deutscher Eisenhüttenleute. The article and discussion discuss control of raw materials, metallurgical processes and finished products of alloy steel. Several examples are given to illustrate the eminent importance of careful control in producing alloy steels. Correct heating temperatures before rolling are especially emphasized and a valuable table for a classification of alloy steels according to their heat conductivity is given. Annealing temperatures for various alloy steels are also considered. GN(6)

**Secondary Brittleness in Rail Steel.** JOHN R. FREEMAN, JR., & G. WILLARD QUICK. *Iron Age*, Mar. 6, 1930, Vol. 125, page 714.

See *Metals & Alloys*, June 1930, Vol. 1, page 567. VSP(6)

**Significance and Evaluation of Fracture Elongation of Metals (Zur Deutung und Bewertung der Bruchdehnung bei Metallen).** W. KUNTZE. *Zeitschrift für Metallkunde*, Jan. 1930, Vol. 22, pages 14–22; Correction, March 1930, page 105.

The present article is a further contribution from the *Staatliches Materialprüfungsamt*, Berlin-Dahlem, undermining the present conception and conventional evaluation of the quality of materials based on the linear elongation at the point of fracture. The author clearly proves that the latter cannot be used for judging metallurgical products. The plastic bending and torsion strength can only be evaluated by means of the total reduction of area and particularly by the maximum linear extension derived from this but cannot be evaluated from the ultimate elongation as ordinarily measured. Subdividing the ultimate elongation into stretching and local restriction the writer proves that the first involves a strain hardening or an increase of resistance to deformation whereas the second is accompanied by a decrease of resistance against deformation, i. e., by a weakening. The evaluation of drawing qualities is not sufficiently determined by the magnitude of this second value because the drawing is usually too small to be compared with a plastic deformation of a local nature. The degree of strain hardening however is more important, which, in case of small extensions, is ordinarily larger than at large deformations. A large local constriction protects against early fracture. The author arrives at the conclusion: The usual statement that the greatest elongation is indicative of safety against fracture is wrong. The ways of more exact, up-to-date evaluation of the discussed values are briefly outlined. EF(6)

**A New Method of Testing Thin Sheets.** *Iron & Coal Trades Review*, Vol. 120, Feb. 28, 1930, page 378.

The Erichsen indentation test presents difficulties in determining the conditions relative to force and deformation. A new method which avoids this disadvantage has been found by a German. A circular hole is made in the sample which is clamped in a special device for making the deep-drawing test. The clamping prevents the sheet as far as possible from being bent in at the outer edge. The material is drawn from the under side of the sample radially over the outside edge of the die, so the hole is widened until the capacity of the material for elongating is exhausted and a fracture produced. RHP(6)

## ELECTRO CHEMISTRY (7)

### Electroplating (7a)

**Effect of Current Density on the Hardness of Electro-Deposited Chromium.** ROBERT J. PIERSOL. *Metal Industry*, N. Y., Dec. 1929, Vol. 27, pages 564–565.

Paper read before the 56th general meeting of the American Electrochemical Society, Sept. 19–21, 1929. Using various current densities from 1 to 7 amp./in.$^2$ it was found hardest when plated at about 4 amp./in.$^2$. The value of this is approximately 43 times as great as that obtained at a normal plating current density of 1 amp./in.$^2$ as shown by abrasion tests. VSP(7a)

**The Electrodeposition of Chromium on Metals.** W. BIRETT. *Metals & Alloys*, March 1930, Vol. 1, pages 432–436; *Brass World*, Vol. 26, April 1930, pages 97–102.

A translation from *Zeitschrift für Metallkunde*, Nov. 1929, Vol. 21, pages 372–377. See *Metals & Alloys*, Vol. 1, March 1930, page 427. EF&ESC(7a)

**Throwing Power in Chromium Plating.** H. L. FARBER (Research Associate, American Electroplaters' Society.) *Metal Industry*, N. Y., Mar. 1930, Vol. 28, pages 124–125; *Brass World*, April 1930, Vol. 26, page 87; *Metal Industry*, (London), Vol. 36, Apr. 4, 1930, page 389.

From the monthly review of the American Electroplaters' Society, Nov. 1929. Gives a summary of the research carried out at the Bureau of Standards. See *Metals & Alloys*, April 1930, page 174. VSP&WHB(7a)

**Production Methods Used in Cadmium Plating.** OTTO H. LOVEN, *Metal Industry*, (N. Y.), Mar. 1930, Vol. 28, pages 127–128.

A description of the mechanical operations involved in quantity work. Considers the comparative value of cadmium as a protection against corrosion. VSP(7a)

**The Production of Electrolytic Iron Printing Plates.** C. T. THOMAS (U. S. Bureau of Engraving and Printing) & W. BLUM (U. S. Bureau of Standards). *Preprint* 57–25, *American Electrochemical Society*, May 29–31 1930, pages 271–283.

Thick printing plates are being made by depositing iron from baths that contain about 3 N $FeCl_2$, 2 to 4 N $CaCl_2$ and 0.01 N HCl. A cathode current density of about 7 amp./sq.dm. (65 amp./ft.$^2$), is used and a temperature of about 90° C. (194° F.). The anodes are suspended in porous alundum diaphragms. The deposited iron has a tensile strength of about 4000 kg./sq. cm. (56,000 lb./in.$^2$) and an elongation of about 20%. The finished plates are plated with chromium to increase the resistance to abrasion. (7a)

**Present Position of Chromium Plating.** *Iron & Coal Trades Review*, Vol. 120, Feb. 7, 1930, page 238; *Foundry Trade Journal*, Feb. 18, 1930, Vol. 42, page 118; *Brass World*, Vol. 26, May 1930, pages 127–128.

Report of a discussion at the meeting of the Electroplaters' and Depositors' Technical Society, held at Northampton Institute, London, Jan. 31, 1930. Chromium plating is most satisfactorily carried out from a solution containing 250 grams/liter, with 2.5 grams of sulphuric acid/liter, a ratio of chromic and sulphuric acid of 100 to 1. Use large lead anodes. Current density about 200 amps. per sq. ft. with a solution temperature of 150° F. Chromium plate over nickel rather than copper for greater corrosion resistance. More concentrated baths with the same ratio are advantageous in many cases. Low temperature of the bath produces bright deposits with lower current densities. Maximum throwing power of chromium is obtained at high temperatures and high current densities. Defects of chromium plating are porosity and the tendency to develop cracks. Suggests that research be undertaken on the use of cadmium as an undercoat for chromium plating. VSP&WHB&RHP(7a)

**Researches on Electro-deposition.** *Engineer*, Vol. 149, Feb. 7, 1930, pages 154–155.

From fourteenth annual report of the Advisory Council for Scientific and Industrial Research. In 1926 the Department Research Committee was appointed to make arrangements for researches on industrial problems of electro-deposition. Those investigations include: work on pitting and porosity in deposits of Ni, Fe and other metals; protection of Al against corrosion by electro-deposition of Zn and Cd; investigation into fundamental aspects of the nature of adhesion and internal stresses in electro-deposits. LM(7a)

**Indium: Recovery by Electrodeposition.** L. R. WESTBROOK. (Grasselli Chemical Co.) *Preprint* 57–22, *American Electrochemical Society*, May 29–31, 1930, pages 239–245.

The comparatively rare element indium is found in very small amounts in process residues obtained in the purification of crude zinc liquors, made from zinc cinder or blende containing traces of it. By treating the crude liquors with metallic zinc, indium if present is precipitated out, together with cadmium, lead, tin, antimony, copper and nickel. Over one pound of the metal was recovered from the residues for experimental purposes. Separation from most of the accompanying elements was accomplished chemically, and the final isolation by electrodeposition of the metal from a citrate bath, representing the best of several electrolytes investigated. (7a)

**Continuous Production in Electro-plating.** J. W. WOLF & M. MICHAELIS. *Metal Industry* (London), Vol. 35, Aug. 16, 1929, pages 151–153; *Zeitschrift Vereins Deutscher Ingenieure*, Vol. 7, May 4, 1929, pages 610–612.

The success which has attended the introduction of continuous methods of production in a number of industries has led to its adoption to a considerable extent in large-scale electro-plating. In automobile and other plants, where quantities of identical parts have to be dealt with, the adoption of continuous production secures a very substantial economy. Details of some recent forms of German continuous plating plant have lately been published. These include an illustrated description of the "Riedel" ring vat, conveyor system, filtration apparatus and heating appliances, with data on the output of nickel-plated bicycle parts obtainable from this type of plant. Ha(7a)

**Plymouth Plating Department Sets a Standard.** V. O. HERB, *Machinery*, Vol. 35, Aug. 1929, pages 881–884.

Economy in production, standardization of a high grade article and the most strenuous safeguarding of the health of the operators have been the factors determining the selection of the electroplating plant in the new Chrysler building, Detroit, where some 1000 steel radiator shells are handled per day. Automatic conveyors eliminate, as far as possible, the manual handling of parts, and efficient ventilation has been scrupulously ensured. The cycle of operations includes a preliminary buffing (on one of 32 Gardner buffing machines), followed by (1) soda ash bath, hot water rinse, electrolytic cleaning, muriatic acid pickle, double cold water rinse, copper plating and rinsing and (2) a repetition of the preliminary cleaning treatments described in (1), a copper "strike" of one minute duration and nickel-plating for 20 minutes. The final operation is that of chromium plating, rinsing and buffing. (7a)

**The Production of Continuous and Seamless Tubing by Electrodeposition.** JEAN BILLITER (University of Vienna). *Preprint* 57–17, *American Electrochemical Society Meeting*, May 29–31, 1930, pages 189–196.

Two electrolytic methods are described for the production of continuous or endless metal (Cu,Fe) tubing. In the first method metal is deposited on a short, slightly conical mandrel of chrome or silicon steel (to which the deposit does not adhere), and at regular time intervals the tube is moved slightly forward over the mandrel, thereby exposing a short, bare section of mandrel. During the next time interval a new deposit forms over this bare section and also over the deposit produced during the previous time interval. In the second method a low-melting hollow mandrel (lead) is slowly passed through a plating cell. (7a)

**Nickel Plate on Aluminum.** C. B. GORDON-SALE. *American Machinist*, Vol. 72, Mar. 6, 1930, page 409.

Nickel plating of aluminum die-casting alloys can be done more successfully by the use of an additional dipping operation after the usual cleaning baths. The solution used is:

| | |
|---|---|
| Nitric acid (conc.) | 68% by weight |
| Sulphuric acid | 30% by weight |
| Ferric chloride | 2% by weight |

Allow parts to remain in this bath 3 or 4 minutes, dip in cold running water and then transfer immediately to the plating bath. RHP(7a)

**Commercial Electroplating on Aluminum.** HAROLD K. WORK. (Aluminum Co. of America.) *Metal Industry*, N. Y., April 1930, pages 173–174.

Describes various Al products that are plated with other metals such as Cr, Ni and Cu. The production of plated Al parts on a large scale was to meet the demand of automobile manufacturers. Numerous other Al products have been plated successfully such as percolators and toasters. Al bars and snare drums have been Cr plated with success. Zn plating of Al has also been successful. Plating of sand castings has not been carried on to any great extent. Al die castings have been plated extensively.
VSP(7a)

**Precision Plating Through Timed Equipment.** G. W. GAMMONS. (General Electric Co.) *American Machinist*, Vol. 72, Mar. 20, 1930, page 492–494.

Describes the automatic equipment of the General Electric Company, Schenectady. One part of the equipment is an automatic cadmium plating machine with capacity for 12,000 average size pieces per 8 hour day.
RHP(7a)

**The Use of Non-Ferrous Metals in the Electroplating Industry.** F. T. TAYLOR. *Mining & Metallurgy*, Vol. 10, Oct. 1929, pages 475–478.
See *Metals & Alloys*, Vol. 1, Jan. 1930, page 342. (7a)

**The Bent Cathode Test for Control of Cyanide Copper Baths.** WALTER L. PINNER (General Spring Bumper Corp.) & EDWIN M. BAKER (University of Michigan). *Preprint* 57–18 *American Electrochemical Society*, May 29–31, 1930, pages 197–203.

In a cyanide copper plating process the constituents of the bath, temperature of operation and cathode current density have a definite effect on the characteristics of the deposit. This is made the basis of an empirical method of control. Certain optimum ratios of free sodium cyanide to sodium copper cyanide are noted, together with corresponding temperatures and current densities. The effects of varying the concentration of the constituents of a typical copper cyanide bath are presented. (7a)

**The Electroplating of Cadmium from Cyanide Baths.** L. R. WESTBROOK. *Transactions American Electrochemical Society*, Vol. 55, 1929, pages 333–348.

The presence of small amounts of nickel in the cadmium bath improves the physical properties of the deposit by making it brighter, harder and denser than deposits obtainable from baths of similar composition containing no nickel. (7a)

**Methods for the Determination of the Absolute Potentials.** JEAN BILLITER. (University of Vienna.) *Preprint* 57–1 *American Electrochemical Society Meeting*, May 29–31, 1930, pages 1–10.

The various methods proposed and used in the past for the determination of the absolute potentials are reviewed and discussed at length. The more recent methods based on the production of fresh metal surfaces give a more reliable value ($\epsilon_H$ + =0.475 volt) which fits in better with our modern physical and chemical conceptions. The older value ($\epsilon_H$ = —0.277 volt) is shown to be out of harmony with these conceptions. Experiments are recorded to show that the older methods ($\epsilon_H$ = —0.277 volt) are misleading. The new scrape method of Bennewitz is recommended as being most trustworthy ($\epsilon_H$ = +0.475 ± 0.005 volt). (7a)

**Addition Agents in Bismuth Electrolytes.** EDWARD F. KERN & THOMAS R. JONES. (Columbia University.) *Preprint* 57–29 *American Electrochemical Society*, May 29–31, 1930, pages 329–347.

Solutions of fluosilicate, fluoborate, creosol sulphonate, perchlorate, fluoride, sulphate and chlorides were tested for electroytes of bismuth, resulting in the selection of bismuth chloride solutions containing sodium chloride, calcium chloride or magnesium chloride as the most suitable electrolytes. The addition agents tried were glue, goulac (sulphite residues), gum arabic, tannin, aloin, aloes Curacoa, hydrochinone, benzoic acid, pyragallol and resorcine. Pyragallol, and resorcine added to the electrolytes, produced the brightest and densest deposits of bismuth; hydrochinone was next in order, benzoic acid next, and the other addition agents were not beneficial. (7a)

**Industrial Education for the Electroplating Industries.** C. L. MANTELL. (Pratt Institute.) *Preprint* 57–13, *American Electrochemical Society*, May 29–31, 1930, pages 139–142.

A new, two-year, intensive course of a non-collegiate type is described. In the course of instruction emphasis is laid on development of practical ability and executive capacity. About one-half of the time is spent in the laboratories, shops and drawing and design rooms. A complete semi-commercial electroplating installation is available for instruction purposes. Furthermore, solutions are analyzed and products are tested. Special study of plating generators and electrical machinery peculiar to the plating industry is included. The demand for the graduates has been in excess of the supply. (7a)

**The Preparation of Pure Electrolytic Nickel. Part I. The Elimination of Copper from Nickel-Copper Electrolytes.** COLIN G. FINK & F. A. ROHRMAN. (Columbia University.) *Preprint* 57–2, *American Electrochemical Society*, May 29–31, 1930, pages 11–24.

The separation of copper from nickel has been a difficult procedure, and has been the subject of investigation for many years. Electrochemical methods, using aqueous solutions, were investigated by the present authors and the effects of pH and other factors studied. It was found that high acidity, low current density, high temperature and vigorous circulation favored the deposition and removal of copper. A rapid method for the removal of copper from nickel solutions is given. (7a)

**Electrode Potentials of Silver in Cyanide Solutions.** COLIN G. FINK (Columbia University) & G. BYRON HOGABOOM, JR. (American Steel and Wire Co.). *Preprint* 57–15, *American Electrochemical Society*, May 29–31, 1930, pages 165–172.

Polarization potentials heretofore recorded for silver in silver cyanide-sodium cyanide solutions have varied widely. Accepted "standard" methods for determining polarization values have given discordant results. The authors, therefore, investigated the behavior of solid silver plate electrodes, and found that the polarization potentials are highest near the upper edge of the square plates and lowest near the lower edge. The difference in values obtained is attributed to the behavior of the solution film next to the electrode surface. Uniformly consistent polarization potential values seem possible only when the surface film is of uniform composition and structure throughout. (7a)

**Some Conductivity Characteristics of Chromic Acid and Chromic Acid Chromium Plating Solutions.** ROBERT H. CHERRY. *Preprint* 57–5, *American Electrochemical Society*, May 29–31, 1930, pages 39–47.

From the standpoint of power consumption the results of this investigation indicate that chromium plating baths should have a concentration of 4.5 molar $CrO_3$ at 45° C. and 3.75 molar at 25° C. It is shown that for all practical purposes the increase of conductivity of chromic acid solutions is a linear function of the temperature, over the range of temperatures covered in plating work. It is shown that the addition of the sulphate ion has the effect of increasing the conductivity of the solution to a maximum when the sulphate ratio is approximately 50, which coincides with the sulphate giving optimum cathode efficiency. Calculations of pH from conductivity data are in fair agreement with the values obtained by other investigators employing potential methods. The hydrogen and quinhydrone electrodes are definitely shown to give erroneous pH values in chromic acid solutions. Furthermore, the platinized-platinum oxygen electrode is shown to be inaccurate in chromic acid solutions. (7a)

**"Stopping Off" Materials for Use in the Electro-Deposition of Nickel.** D. J. MACNAUGHTON & A. W. HOTHERSALL. (Research Department, Woolwich.) *Transactions Faraday Society*, Vol. 26, April 1930, pages 163–172; *Engineering*, Vol. 129, April 25, 1930, page 536.

Various insulating coatings were tested including oil varnishes, cellulose ester varnishes and wax mixtures. Cellulose ester type of varnish known as Necol varnish was found to be satisfactory if properly applied. Mixtures of paraffin wax with gutta-percha or bitumen had some advantages over the Necol varnish. They could be applied more rapidly and they were more free from pinholes. Discusses contamination of Ni depositing solutions by insulating materials. Includes photographs and tables.
LM(7a)

**Electrodeposition of Copper-Nickel Alloys.** LAWRENCE E. STOUT, OSCAR G. BURCH & A. S. LANGSDORF. (Washington University.) *Preprint* 57–16, *American Electrochemical Society*, May 29–31, 1930, pages 173–187.

Quantitative data on the factors controlling the percentage composition of an electrically deposited alloy are meager, except for a few isolated binary and ternary systems. This study of the deposit obtained from the copper-nickel system shows that: (1) the percent of copper in the plate is always greater than that of the bath, the difference becoming progressively greater as the copper content of the bath increases; (2) the ratio of copper to nickel on the plate increases linearly with the temperature; and (3) low current densities favor the deposition of high copper alloys. Increase in free cyanide content was found to decrease the rate of deposition, agreeing with the observations made by Kremann on the copper–tin and copper–antimony systems. Probable empirical equations to fit the data are given. (7a)

**Studies in the Electro-Deposition of Nickel. Part I. The Effect of pH and of Various Buffering Agents; the Presence of Oxygen in the Deposits.** J. B. O'SULLIVAN. (Sir John Cass Technical Institute.) *Transactions Faraday Society*, Vol. 26, Feb. 1930, pages 89–94; *Metal Industry*, Vol. 36, Jan. 3, 1930, pages 8–10.

Includes discussion. Suggests that fine grain structure of Ni deposits may be accounted for by the fact that a small amount of colloidal hydroxide is always deposited with the Ni, even from fairly acid solutions. This may also explain why Ni plating solutions are always sensitive to colloidal addition agents. Results indicated that oxygen was present in deposits in amounts varying from 0.01 – 0.04%. Author felt that these results were not conclusive due to difficulty in making oxygen determination.
LM(7a)

**Protective Value of Some Electro-Deposited Coatings.** L. DAVIES & L. WRIGHT. *Journal Institute of Metals, Advance Copy* 517 (1930), 12 pages; *Engineering*, Vol. 129, Mar. 21, 1930, pages 389–390; *Automotive Industry*, Vol. 62, Apr. 19, 1930, pages 624–627; *Metal Industry* (London), Vol. 36, Apr. 11, 1930, pages 407–410.

This paper deals with a series of salt spray tests and sulphuric acid spray tests on a number of specimens of steel, brass, copper and phosphor-bronze plated with cadmium, zinc, nickel and chromium. Tests were made with chromium plate direct on the base metal and also with a nickel undercoat. Thicknesses of the chromium deposits varied from 0.0001 in. – 0.002 in., and were of thicknesses frequently used in commercial specifications. Deposits of zinc and cadmium gave little protection in either the salt spray or sulphuric acid test, in the case of the non-ferrous metal base. Nickel and chromium afforded good protection under both sets of conditions. The best protection on a non-ferrous metal basis was afforded with a 0.002 in. coating of nickel. On steel the cadmium deposit gave a better protection than a zinc coating with the sulphuric acid spray test, but with chloride spray the thinner coatings of zinc gave better protection than the corresponding cadmium coatings. Chromium deposits were found to be useless on steel in either spray. The best protection with nickel was obtained with 0.002 in. deposit. The value of this thickness was greater than it would have been if the protection afforded were proportional to the thickness. The authors suggest that a heavy coating of nickel is the most generally serviceable deposit. AEH & LM(7a)

## Electrometallurgy (7b)

**The Series System of Electrolytic Copper Refining at Nichols Copper Co.** FRANK R. CORWIN & CARLETON S. HARLOFF. (Nichols Copper Company.) *Preprint* 57–23, *American Electrochemical Society*, May 29–31, 1930, pages 247–256.

During recent years, the Nichols Series System of Electrolytic Refining has been developed so that improvements made, together with its inherent qualifications, have placed it in a strong, competitive position with the multiple system as to quality of production, grade of material handled, cost of production, tie-up of metals in process and precious metal loss to cathode. (7b)

**Status of Electrolysis as a Metallurgical Process.** T. H. DONAHUE. (Anaconda Lead Products Co.) *Preprint* 57–20, *American Electrochemical Society*, May 29–31, 1930, pages 213–232.

Through the introduction of electrolytic methods and flotation the metallurgical art of processing ores has undergone important changes during the last 25 years. A brief review of the status of each of the following metals is submitted: Copper, zinc, lead, cadmium, silver, bismuth and nickel. The difficulties of the present electrolytic processes are examined. The importance of precious metal by-products is emphasized. Improvements in process and possible introduction of new methods are discussed. Many novel industrial applications of electrolytic methods to the above and to other metals are suggested. (7b)

**The Betts Electrolytic Lead Refining Process in Practice.** J. J. FINGLAND. (Consolidated Mining & Smelting Company of Canada.) *Preprint* 57–10, *American Electrochemical Society*, May 29–31, 1930, pages 85–112; *Chemical Trade Journal*, Vol. 87, July 1930, page 39.

The Trail electrolytic lead plant is the pioneer Betts' plant. The cells, arranged in multiple and cascade, are made of concrete and lined with asphaltum. The general layout of the cell room is similar to that of the copper refinery at Great Falls. For the circulation of the electrolyte, plunger and centrifugal pumps constructed of copper with monel metal wearing parts are used. Details as to equipment and operation are given. Much higher percentages of impurities (up to 2%) are permissible in the lead anodes than in the respective copper anodes. Silver in the cathodes must be kept as low as 2 to 7.5 mg./kg. of refined lead. The usual impurities in the lead bullion (anodes) are commonly present in such proportions that they will remain in the antimony slime sponge; copper is an exception. Copper present in the bullion in excess of 0.04% will form a hard skin on the surface of the anode insoluble in hydrofluosilicic acid. The electrolyte demands frequent analytical control. Methods for the production of $H_2SiF_6$ are given in detail. Due largely to the accumulation of the antimony sponge on the anode surface, the initial cell potential of 0.35 volt rises during the course of days to 0.70 volt (at 2 amp./sq. dm.). Control of the $H_2SiF_6$ content of the sponge is important. The treatment of the anode sponge for the recovery of gold and silver presents no unsuual features. About 80% of the bismuth contained in the bullion is found concentrated in the copper oxide slag recovered just prior to the finishing of the doré charge. WHB(7b)

**Electrometallurgy of Zinc According to the Latest Data. (L'etat actuel de la metallurgie electrolytique du zinc d'apres les dernieres publications.)** A. SANSON. *Revue de Metallurgie*, Vol. 27, Feb. 1930, pages 57–63.

A brief outline of the present state of electrometallurgy of zinc in America and Europe. Commercial aspects are discussed. Electrolytic methods can supplant distillation in large scale production, the latter is more advantageous when coal and labor are cheap and the plants already amortized. A detailed description of the practice at Anaconda and Great Falls is given being an abbreviation of the paper on the subject published by Albert E. Wiggin and Russel B. Caples in *Engineeaing & Mining Journal* Vol. 128, Aug. 1929. JDG(7b)

**The Electrolytic Zinc Plant of the Evans-Wallower Company at East St. Louis, Ill.** U. C. TAINTON AND DANIEL BOSQUI. (The Evans-Wallower Zinc Co.) *Preprint* 57–27, *American Electrochemical Society*, May 29–31, 1930, pages 311–320.

The Joplin district will probably continue for many years to be the chief zinc producing district of the United States. Hitherto, all zinc from this field has been produced by the old process of retort smelting and the paper describes the first plant to treat these ores by electrolytic methods. Flotation concentrates are roasted in Wedge furnaces, the roaster gas being converted to sulphuric acid by the contact process. After passing over magnetic separators, the concentrates are leached in spent electrolyte (28% $H_2SO_4$). The heat of the reaction raises the temperature to boiling point. Residue containing lead, silver and gold, are shipped to the lead smelter. Leached solution is purified with zinc dust to precipitate copper, cadmium, cobalt and nickel. The cadmium is separated from the copper and recovered electrolytically, while the cement copper goes to a copper smelter. In the zinc cells aluminum cathodes are used at a current density of 100 amp./ft.$^2$ (10.7 amp./ dm.$^2$). Anodes are in grid form, and are composed of lead alloy containing 1% of silver. During electrolysis, manganese dioxide is precipitated, yielding a high grade product free from iron, copper, nickel, etc. The electrolytic zinc produced is 99.99% pure. The daily capacity of the plant is 50 tons of electrolytic zinc, and 1000 lbs. (454 kg.) of cadmium. (7b)

## METALLIC COATINGS OTHER THAN ELECTROPLATING (8)

**Factors Affecting the Quality of Zinc for Galvanizing.** WALLACE G IMHOFF. *Metal Industry* (N. Y.), Vol. 28, Mar. 1930, pages 113–115.

Two features of importance regarding zinc for galvanizing are quality and cost. Physical appearance and the handling of the metal show many characteristics. Total metal charged was 78 tons and dirt scraped off prior to galvanizing was 1785 lbs. Figures for high quality zinc show less than 0.5% of dirt after melting. Skimmings from average brand of zinc will be about 1.00–1.20%, and high quality zinc about 0.50% or less. Gives analyses of 5 brands of zinc which did not fall within that specified as Prime Western. Clean, high quality zinc has a lower specific gravity. Lead, tin and iron tend to increase the specific gravity. Reclaimed zinc can be good if temperature of reclaiming is not over 840° F. VSP(8)

## INDUSTRIAL USES AND APPLICATIONS (9)

**Minor Alkali Metals Have Various Odd Uses.** *Metals & Alloys*, Vol. 1, May 1930, pages 507, 536.

A discussion of information circular No. 6215 "Calcium, Rubidium and Lithium" U. S. Bureau of Mines, Department of Commerce. An account of the mineral sources and the discovery of the alkali metals together with a description of the principal uses is offered. ESC(9)

**Alloy Steels in Locomotive Construction.** W. M. BARR. *Railway Age*, Vol. 87, Nov. 30, 1929, pages 1299–1300; *Railway Mechanical Engineer*, Vol. 103, Dec. 1929, pages 739–742, 747; *Proceedings Western Railway Club*, Vol. 42, Nov. 1929, pages 10–27.

A paper presented to the Western Railway Club in Chicago, November 18. The transition from chromium, vanadium and nickel was described along with the troubles that were encountered not only by the steel maker, but also by the fabricator. This was one of the earliest applications of large alloy steel sections in tonnage quantities and hence many defects traceable to manufacturing methods were soon disclosed. Following the solutions of these difficulties, attention was turned to problems developing as a result of design, machining methods, operating methods, etc.; marked improvement has now been effected by suitable education of personnel. Inadequate lubrication is still, however, a fruitful source of failures originating in surface ruptures occurring at hot bearing surfaces. With the great weight and size of present-day locomotives, the trend is now toward the development of more power by increased boiler pressures. In order to build boilers to withstand these higher pressures safely without increasing the thickness of the shell, designers are giving consideration to the use of alloy plates. Alloy steels containing 2 and 3% of nickel have been used with satisfactory results. Plate has been made from steel containing 1% of chromium with 0.15% vanadium, which shows unusually satisfactory physical properties and this steel will, no doubt, be tested in boiler construction. In the construction of these boilers, strength and workability of the metal must be first considered. Although carbon steel is still in general use in spring construction, much work has been done to develop a spring material of alloy steel that will increase the life of the springs and reduce breakage. Chrome-vanadium has been used more than any other for this purpose. (9)

**Progress in the Manufacture of Alloy Steel.** S. J. HEWITT. (Edgar Allen & Co.) *Edgar Allen News*, Vol. 9, June 1930, pages 636–637; *Industrial Chemist*, Vol. 6, Jan. 1930, pages 34–35.

Gives specifications of the more important steels used in the motor industry. MLM(9)

**Corrosion-Resisting Materials for Dyeing Plants.** A. A. POLLITT. *The Dyer, Calico Printer, Bleacher, Finisher and Textile Review*, Vol. 50, Nov. 1929, pages 577–579, 581.

Development of special metals. The applications of Monel Metal, nickel and stainless steels are discussed. (9)

**Resistance of Rails Against Breakage and Wear: Rail Joints.** *Engineer*, April 25, 1930, Vol. 149, p. 467.

Advance notice of reports presented before the International Railway Congress, Madrid, May 5, 1930. First report is by R. B. Abbott who discusses American rail problems. Report No. 2 is by Messrs. Cambourac and Patte covering all countries except America, British Empire, Japan and China. Report No. 3 is by S. Matsunawa which covers the British Empire, Japan and China. The London and North Eastern Railroad reports that life of chrome steel and manganese steel rails is 1.2 times and 3 to 4 times respectively as long as that of ordinary carbon steel rails. Southern Railway reports that life of rails containing 1% Cr is more than twice that of ordinary steel, but evidence of brittleness has been noted. Abrasion tests carried out by New South Wales Government Railways show that manganese steel rail is best, followed by silicon. Nickel steel rail is inferior to ordinary carbon steel rail. Japanese government tests showed that manganese steel rails have average life of 5 or 6 times that of carbon steel rails which economically justifies their use. LM(9)

**Nickel-Alloy Steels in the Daimler Double-six.** *Nickel Bulletin*, Vol. 2, Nov. 1929, pages 133–142.

Nickel alloy steels are used in automobile construction to insure reliable service under all conditions. Considers physical properties of steels used in different parts of the car. MLM(9)

**High Pressures and Temperatures.** O. A. WIBERG. *Engineer*, Vol. 148, Nov. 15, 1929, pages 515–516.

Abstract from the paper presented at the Steam Turbine Conference held during the World Power Conference at Tokio, 1929. Discussion on the physical properties of steels and alloys. The data include short-time tensile, creep and fatigue tests up to 700° C. (9)

**Some Materials Used for Naval Engineering Purposes.** J. HOPE HARRISON. *Engineer*, Vol. 149, April 18, 1930, pages 440–442; *Engineering*, Vol. 129, April 11, 1930, pages 473–476.

Condensed from paper read before Institution of Naval Architects, April 9, 1930. Summarizes service behavior of some materials used for machinery purposes in naval service. Discusses heat-resisting steels, metals used for boiler and condenser tubes, steel castings, steel forgings, cast-iron, use of Al, brasses and bronzes and P. M. G. metal which is a Cu-Si alloy. LM(9)

**Metals are Indispensable in the Air.** J. F. HARDECKER. *Metal Industry* (New York), Vol. 27, July 1929, pages 315–318.

Data are given on the aeronautical applications of copper, the brasses and bronzes, monel metal and babbitt alloy. The value of monel metal for use in aircraft lies in its high strength/weight ratio and its immunity from corrosion. It is being employed for exhaust manifolds, propeller sheathing, carbureter needles, etc., and is in experimental use for gasoline and oil tanks, wheels, bolts, nuts and other parts. The article contains reference to the recent completion of two all-monel metal seaplane floats, which exceed the weight of similar duralumin floats by less than 10%, and have the very signal advantage over duralumin that they require no form of protective coating or treatment to produce the required resistance to sea-water attack. (9)

**Chromium-Nickel Alloys for Sulphite Equipment.** L. W. GIBBONS. *Paper Trade Journal*, Vol. 88, May, 1929, pages 61–63.

Paper gives the following list of parts of sulphite mill plant which are being successfully made from nickel-chromium steels of the 8/18 type: Tie rods for liquor storage tanks, tank outlets, piping, pumps, parts of circulating systems on sulphite digesters, strainers of various types, relief ines, valves, steam lines to digesters, tubing for coolers, cooler coils, blow-off fillings, seats and discs for blow-off valves, target plates, nails, blow-off pits. All these parts have been successfully fabricated in the nickel-chromium corrosion-resisting steel, and the material is standing up well under service conditions. (9)

**Cast Steel as Material for Machine Construction. (Stahlguss als Werkstoff des Maschinenbaus.)** F. W. DUESING. *Stahl und Eisen*, April 3, 1930, Vol. 50, pages 438–440.

After outlining the importance of cast steel for machine construction, production, properties, heat treatment and the German standards for cast steel are dealt with. The frequency of obtainable properties, as yield point, tensile strength, elongation and reduction of area, in testing a great number of samples are given in diagrams. As results from these curves of frequency there is no difficulty in keeping the properties within the standard limits. GN(9)

**Aluminum Gaining in Favor for Car Construction.** CLIFFORD A. FAUST. *Electric Railway Journal*, April 1930, Vol. 74, pages 184–190.

Experience with many vehicles built largely of aluminum alloys has proved the economic value of this material from operative and maintenance standpoints. A table shows "equipment in which aluminum has been used with weight data and other pertinent information." Numerous types of trolley cars and a railroad car are illustrated. WHB(9)

**Alloy Steel Sheets for Aircraft.** J. B. JOHNSON. *Iron Age*, Feb. 13, 1930, Vol. 125, pages 502–505.

Alloy steel which has been used most generally is a chrome-molybdenum, steel conforming to the analysis of the alloy steel tube which has been adopted as standard in airplane industry. Three types are used, namely, cold rolled, annealed and normalized. A special chrome-molybdenum steel has been developed which can be fabricated into fittings and then welded. It is a hot-rolled product. Contains numerous tables giving physical properties of cold rolled sheets and chemical and physical properties of special chrome-molybdenum steel before and after heat treatment. VSP(9)

**Cylinder Heads of Aluminium Alloys.** GEORGE MORTIMER. *Metal Industry* (London), Jan. 10, 1930, Vol. 36, pages 35–36; *Canadian Foundryman*, Vol. 20, Nov. 1929, pages 12–14.

Engines fitted with aluminum pistons showed a marked improvement in performance. The chief advantage of aluminum pistons was in the high thermal conductivity. Thermal conductivity of aluminum and its light alloys increases with rise in temperature, that of cast iron decreases as temperature rises. Considers also other advantages of aluminum pistons over cast iron for internal combustion engines. VSP(9)

**Various Steels Are Used for Gears.** N. L. DEUBLE. *Iron Age*, Feb. 13, 1930, Vol. 125, pages 506–508.

Discusses small gears used in automobile transmission and differentials. The steels are of 2 kinds: full-hardening chromium steels and carburizing nickel steels. Chromium steels for gears range in carbon from 0.30–0.55%, and 0.47–0.52% carbon and 0.80–1.10% chromium. Gear blanks are forged at temperature under 2250° F. For truck and tractor gears a carburizing grade is used because of the high tooth pressures, large amount of gear work and shock stresses. Hard surface of carburized gears resist wear, and the core provides resistance to shock. Many steels are used for carburized gears, but nickel steels predominate. VSP(9)

**Commercial Application of Beryllium.** *Metal Industry* (London), Jan. 10, 1930, Vol. 36, page 36.

Commercial application of beryllium is limited on account of its high cost. Various processes have been worked out of extracting it from its ores. Considerable research has been carried on toward the development of uses for beryllium. A German company is concentrating chiefly upon alloys of beryllium with heavy metals such as iron, copper and nickel. It is claimed that beryllium hardens iron. In the United States alloys of beryllium with gold and silver have been produced. It is also used for electrodes in neon signs. VSP(9)

**Vanadium Steels for Railroad Springs.** *Vancoram Review*, Jan. 1930, Vol. 1, pages 39–41; *Iron Age*, Feb. 13, 1930, Vol. 125, page 525.

Discusses the use of vanadium steel instead of high carbon spring steel. VSP(9)

**Magnesium and Its Alloys in Aircraft.** H. G. HARVEY. *Metals & Alloys*, Feb. 1930, Vol. 1, pages 365–367; *Heat Treating & Forging*, Vol. 15, Oct. 1929, pages 1317–1319.

Paper presented at the Fifty-sixth General Meeting of the American Electrochemical Society, Pittsburgh, Pa., Sept. 1929. See *Metals & Alloys*, Feb. 1930, Vol. 1, page 385. ESC(9)

**Type Metals in the Newspaper Industry.** JOHN HELFRICH. *Metals & Alloys*, March 1930, Vol. 1, pages 420–421.

Type metals are composed of varying percentages of tin, antimony and lead. The composition depending upon the properties desired in the resulting casting. A table of composition of various type metals and their respective applications is included. Although superficial analytical observations of type metals have been made there is no evidence of real study of this problem. Sampling for analysis should be done with great care. No precision is exercised in "drossing" the type metal which consists in fluxing used type metals at regular intervals with a variety of materials. There is evidence of undesirable properties in dross metal. Some evidence is presented to indicate that the pigments have a deleterious effect upon the properties of the metal. ESC(9)

**Annual Report of the Public Printer for 1929.** G. H. CARTER. U. S. Government Printing Office, 1930.

This contains several references to the replacement of gas heated pots for melting type metal by electrically heated pots, which are said to have increased the quality of the type, and decreased the room-temperature which was almost unbearable with gas-heated pots. The Technical Director reports, on pages 118–123, on the coöperative investigation undertaken in conjunction with the Mechanical Department of the American Newspaper Publishers' Association. Five large newspapers submitted regular samples of their linotype and stereotype metals over a period of some two years. The extreme ranges of composition met in tin and antimony were from 3.25–4.60% Sn and 11.15–12.45% Sb in linotype metal, and 4.25–7.45% Sn and 12.65–14.85% Sb in stereotype metal. No trouble was met within these ranges, and while the opinion is expressed that 3.25% Sn in linotype is near the danger point, no definite evidence was obtained as to the exact lower limits for Sn and Sb. The standards aimed at by the newspapers varied, among the five cooperators from 3.75–4.25% Sn and 11–12% Sb for linotype, from 5–7% Sn and 13.5–15% Sb for stereotype. The standard formulae for the Government Printing Office are given as 4.4% Sn, 11.5% Sb for linotype, and 7.3% Sn, 16.8% Sb for stereotype. The balance in all these alloys, save for copper which runs from below 0.05–0.12%, is lead. The Government Printing Office alone has in service more than $7\frac{1}{2}$ million pounds of type metals. HWG(9)

**Alloys for Cable Sheathing.** R. S. DEAN & J. E. RYJORD. *Metals & Alloys*, March 1930, Vol. 1, pages 410–414.

Cable sheath alloys must be pliable and capable of forming into sheathing at a temperature which will not damage the paper insulating material. Lead is the only common and cheap material which meets these requirements. In service the sheath requires resistance to corrosion and to failure from fatigue and tensile stresses. It has been found that a small amount of a second element in solid solution prevents intercrystalline breakdown under corrosion. Consequently most all high lead alloys are suitable from a corrosion standpoint. The study then concerns mechanical properties which affect extrudability and durability in service. A tensile strength of 4000 lbs./in.$^2$ seems most desirable. One percent antimony alloy is extruded as a solid solution. This breaks down at ordinary temperatures to yield the antimony dispersed throughout the lead in fine particles. Accompanying this is an increase of tensile strength from 3000–4000 lbs./in.$^2$ Agglomeration due to cold working, however, indicates a necessity for improvement by means of some other alloy. The lead-calcium system indicates desirable alloys in the range 0.03–0.04% calcium. The $Pb_3Ca$ particles show great reluctance to grow as compared with the antimony alloy precipitation even under cold working. Curves show the effect of percent of calcium on the hardness after aging at various temperatures from 100–150°. The strength varies from 2000–7000 lbs./in.$^2$ Curves are given showing the effect of various quenching temperatures on alloys of varying compositions. The desired tensile strength can be best obtained with 0.03–0.04% calcium alloys extruded over a range of temperatures. Values of fatigue tests given corroborate this observation. One percent calcium lead alloy is dissolved in lead to yield the required composition. The former having been prepared by electrolysis of fused calcium chloride with a carbon anode and molten lead as a cathode. Curves are given showing wide range of extrusion temperatures to yield desirable properties of the 0.03–0.04% alloy. Curves showing dynamic and static fatigue tests are shown. ESC(9)

**Metallurgy of Valve, Fitting and Piping Materials. Some Fundamentals.** L. W. SPRING & H. W. MAACK. *Metals & Alloys*, April 1, 1930, Vol. 1, pages 446–449.

Twenty-five years ago temperatures of 300–400° F. and pressures of 100 or 200 lbs./in.$^2$ were utilized in the steam industry. Modern practice requires pressures of 1500 lbs./in.$^2$ and temperatures as high as 900° F. in some applications. For steam valves Monel Metal has replaced brass and cast iron to accommodate temperature expansion and resist corrosion. The oil industry has adopted chrome iron valves to resist sulphurous fumes. Hydrochloric acid containing oils are best confined with acid bronze valves. The washing process requiring acid and alkali in turn has been best resisted by bronze with high lead content, copper-tin bronze (10% tin) and finally copper nickel alloy (1:3). Silver is satisfactory for valve seats to resist the action of chlorine. Nitralloy has proved non-corrosive and shows no tendency to seize or tear when used as a valve seat. Contamination of liquors such as photographic developer is prevented by the use of pure nickel valves. Pure tin, nickel, Monel Metal, aluminum and the chrome-nickel-iron alloys are best for foods, fruit juices, etc. Chrome iron alloys, chrome nickel iron alloys and aluminum are satisfactory for nitric acid service. Sulphuric acid sp. gr. 1.84 is satisfactorily handled with iron or steel. Dilute sulphuric sp. gr. 1.70 requires acid bronze of copper and tin or copper and lead. Duriron cast iron 12–14% Si is satisfactory for weak acid service where great strength is not required. 18–8% chrome-nickel is highly satisfactory for digester linings in the sulphite paper industry. ESC(9)

**Recent Improvements in American Locomotive Construction.** E. MEZELTIN. *Zeitschrift Verein Deutscher Ingenieure*, Vol. 73, Aug. 3, 1929, page 1087; Aug. 17, 1929, page 1159.

Typical modifications of design are discussed and illustrated, and reference is also made to new materials which have been introduced with a view to increasing tractive capacity and lessening weight. In this connection mention is made of the extensive use of nickel steel by the Canadian Pacific Railway, in whose most up-to-date locomotives nickel steel is specified for boilers, staybolts, fireboxes and other parts. Ha(9)

**Alloy Steels.** C. E. MACQUIGG. *Iron & Coal Trades Review*, Vol 120. Feb. 28, 1930, page 370.

Abstract of a paper entitled, "Recent Developments in Applications of Steels" read before the American Institute of Mining and Metallurgical Engineers at New York. See *Metals & Alloys*, Vol. 1, June 1930, page 566. RHP(9)

**Chains.** *Engineering*, Vol. 129, Feb. 21, 1930, page 241.

From "Memorandum on Chains and Other Lifting Appliances" by G. S. Taylor issued by H. M. Stationery Office, 1929. For chains the strength of the iron is of secondary importance in comparison to its welding qualities and ductility. Briefly discusses these factors giving figures for four representative chain irons showing their ultimate strength, elongation and reduction of area. LM(9)

**Nickel Cast Iron Proves a Useful Alloy.** *Engineering & Mining Journal*, Vol. 129, May 23, 1930, page 522.

A nickel-cast iron has been effectively applied in general machinery, machine-tool, power fields and automotive and aeronautical industries. The nickel content varies between 0.5–1.5 in various types of usages. WHB(9)

**Chromium-Copper Structural Steels.** J. A. JONES. *Journal Iron & Steel Institute*, May 1930, *Advance Copy* 8, 9 pages; *Engineer*, Vol. 149, May 16, 1930, page 539; *Engineering*, Vol. 129, May 23, 1930, page 687.

The author has investigated steels containing about 0.30% carbon, 0.50–1.00% manganese, up to 1.5% chromium and up to 1.2% copper. It was found that steels containing chromium in addition to manganese do not offer any advantage for structural purposes over the usual type of steel containing high manganese only. The addition of from 0.5–1.2% of copper to steels containing up to 1% of chromium leads to a marked improvement in the properties. In addition to their improved resistance to atmospheric corrosion, steels containing about 1% of copper offer the further advantage that they are less sensitive to variations in the rate of cooling after normalizing. Within the range of composition investigated, the best properties were obtained in a steel containing 0.3% carbon, 0.5% manganese, 0.9% chromium and 1.2% copper. The mechanical properties of this steel compare favorably with those of the best manganese-silicon structural steels, and are better than those obtainable in high manganese structural steels. LM&AE H(9)

**Turbine Blading Steels.** ROBERT HADFIELD. *Marine Engineer & Motorship Builder*, Vol. 52, Nov. 1929, pages 459–460.

In view of the importance in modern turbines of blading materials which will withstand very severe conditions of pressure and temperature, attention is drawn to the development of a series of high-nickel, high-chromium steels which most successfully resist the combined corrosive and erosive attack involved. The steel in question, "Hecla A.T.V." was developed primarily with a view to securing a material which would be immune from fissuring effects when in contact with superheated steam. It also possesses the valuable quality of being resistant to embrittlement by hydrogen and other gases, and has the added advantage of retaining a very high proportion of its mechanical strength at high temperature, and of possessing a high fatigue limit. A number of comparative experiments, under conditions simulating closely those obtaining in turbines, have indicated very clearly the superiority of the A. T. V. alloy as compared with any other blading material yet known, and the results so obtained are unequivocally supported by practical experience in large-scale installations. The author cites striking figures relating to comparative service, in a large power station, of blading of 5% nickel steel and of "Hecla A. T. V." alloy. The high chloride content of the water in this plant renders the attack on the turbine blading specially severe, and the length of life which is being obtained from the A. T. V. material provides the strongest possible proof of its ability to withstand the severest of conditions. (9)

**Corrosion-Resistant Steels for the Paper Industry.** J. A. MATHEWS. *Paper Trade Journal*, Vol. 88, May 23, 1929, pages 79–81.

Lecture delivered before the Technical Association of Paper and Pulp Manufacturers at their 1929 assembly. In view of the prevalence of the attack of sulphur dioxide and sulphurous acid in paper making, the speaker presented some data relative to the effect of these reagents on corrosion-resisting steels of the high-chromium and high-nickel, high-chromium types; the results reported are based on tests made by paper manufactures in sulphite digestors. They indicate that steels containing 24–27% of chromium and nickel-chromium-silicon steel (nickel 18.5, chromium 9%) show excellent behavior in contact with the corrosives occurring in paper manufacture; in both cases the steels remained perfectly bright at the end of a 30 days' test in the digestors. Considerations of fabrication, combined with its superior impact strength, make the latter material the more suitable for paper-making plant. In view of the use, in certain branches of the industry, of alkalies and alkaline sulphides, the author gives particulars of the resistance of chromium and nickel-chromium-silicon steels to "black liquor," a complex solution containing 9–10% of inorganic matter (consisting of sodium carbonate, caustic soda, sodium sulphide, sodium chloride, sodium sulphate and other substances). The resistance of all the types of chromium and nickel-chromium-silicon steels tested was entirely satisfactory. From a consideration of the data presented, the author concludes that the corrosion-resisting steels of the types described offer very great possibilities to the paper industry; they promise substantial diminution in maintenance and repair costs, with reliable and continuous operation. (9)

**The 1500 lb. Pressure Steam Plant at Mannheim Power Station.** F. MARGUERRE. *Engineering*, Vol. 128, Aug. 23, 1929, page 225; Aug. 30, 1929, page 252.

Description of the 15,000-lb. pressure steam plant at Mannheim Power Station, an installation which presents a number of features of special interest. The material chosen for the drums of the boilers was a $1\frac{1}{2}$% nickel steel, known as "Krupp Mark F.," the high temperature mechanical properties of which allow of a saving in weight, while the hardness insures a minimum deformation due to tube expansion. The $1\frac{1}{2}$% nickel steel presented an additional advantage for the purpose under consideration in that when used in conjunction with carbon tubes no electrolytic action occurs. Special requirements were postulated in connection with the superheaters, in view of the possibility that the very high normal superheat (470° C.: 878° F.) may at times be exceeded so that the tube walls are subjected to temperatures at which the limiting creep stress of plain carbon steels is exceedingly low. Alloy steels were, therefore, selected and the superheaters were constructed in 2 sections, nickel steel headers and plain steel tubes being used in the region of lower temperature, while nickel steel tubes and nickel-chromium steel headers were employed in the section exposed to higher temperatures. The whole of the material used complied with the specifications of the Vereinigung der Grosskesselbesitzer, with the addition of specially stringent requirements in certain special portions of the plant. Soft iron, nickel and Monel Metal have been used as packing materials in the high pressure steam pipe system, and the flange bolts are of nickel-chromium steel, a high-tensile nickel-chromium steel also being used for the expansion bends of the piping in this portion of the plant. Krupp V 2A steel (nickel-chromium corrosion-resisting steel) was selected for seatings of reducing valves and branch pieces are of same material. (9)

**The Applications of Monel Metal in Engineering and Shipbuilding.** J. IRELAND. *Institution of Engineers and Shipbuilders in Scotland, Advance Copy*, July 1929; *Metal Industry* (London), Vol. 35, July 26, 1929, page 87.

A paper read before a joint meeting of the Institution of Engineers and Shipbuilders in Scotland and the North East Coast Institution gives a comprehensive survey of the properties of monel metal and of its applications in the engineering and shipbuilding industries. The qualities of monel metal may be regarded as being an optimum combination of the strength and hardness of nickel with the toughness of copper and the resistance to corrosion of both metals. Some comparative data are presented on the maximum, tensile and impact strength and the limiting creep stress of monel metal, mild steel and a number of other materials, both at normal and at elevated temperatures, demonstrating the striking combination of strength and toughness exhibited by monel metal. The degree to which the alloy maintains these high mechanical properties at raised temperature, i. e., within the range met with in steam practice, makes it particularly useful in power plant working at high pressure and temperatures. The author describes the conditions requisite for the successful fabrication, machining, welding and heat-treatment of monel metal and illustrates its remarkable corrosion-resisting properties by reference to the practical uses to which it has been put in chemical plant, pickling apparatus, power plant, etc. In a very large number of industries the introduction of monel metal equipment has proved to be the solution of long-standing corrosion problems, and has resulted in almost revolutionary economy in replacement requirements. (9)

## HEAT TREATMENT (10)

**The Heat Treatment of Steel.** *Engineering*, Vol. 129, Jan. 31, 1930, pages 141–142.

Editorial commenting on paper by H. Rickli read before the World Power Conference in Tokyo. Attention was drawn to the cases in which attempt to improve properties of alloy steels by heat treatment had been responsible for explosion of rotors of high-speed three phase alternators. Cause of accidents cited is due to internal stresses set up by heat treatment. Gives other instances of failures due to same cause. Recommends use of rotor built up of discs. Disc is rough finished and then run up to a high speed in the bomb-proof to stretch it permanently. It is then finish-machined. It would then have proper distribution of internal stresses, better magnetic qualities and would distort less if accidentally over-speeded. LM(10)

**Heat Treatment of Steel.** H. Pennington. *Oil Weekly*, Vol. 54, Aug. 23, 1929, pages 27–29.

Molybdenum steels, S. A. E. 4000 series; chromium steels, S. A. E. 5000 series; vanadiumstee ls, S. A. E. 6000 series; manganese steel; describes influence of mass and of unequal expansion in heat treatment of irregular sections. (10)

**Heat Treatment of Complex Ferro-Nickels Containing Two Constituents. (Traitement thermique des ferronickels complexes à deux constituents.)** P. Chevenard. *Comptes Rendus*, Vol. 189, Nov. 18, 1929, pages 846–849.

The addition of another element such as copper or aluminum to ferro-nickel alloys results in the formation of two phases, the mutual solubility of which increases with temperature. These alloys show, after quenching, the same aging properties as duralumin, the slow precipitation of a hard constituent from the supercooled solid solution resulting in improved mechanical properties. The alloys show a hysteresis loop in the dilation-temperature curve. (10)

### Annealing (10b)

**Shortens Malleable Anneal.** *Foundry*, Vol. 57, Oct. 1, 1929, pages 825–826.

See *Metals & Alloys*, Vol. 1, Nov. 1929, pages 233–234. VSP(10b)

**Short Annealing for Malleable Iron.** *Engineer*, Vol. 149, March 14, 1930, page 298.

Outlines very briefly method used by General Electric Company for treating malleable iron castings by short cycle annealing process in electric furnaces. See *Metals & Alloys*, Vol. 1, March 1930, page 429. LM(10b)

**The Grünewald Bright-Annealing Process.** *Engineering*, Vol. 129, April 4, 1930, page 442.

Describes plant made by General Electric Company particularly adapted for bright annealing of steel, Cu strip or wire. Air is completely excluded from metal under treatment. Pot is sealed by means of rubber ring. As contents heat, air is discharged through valve in cover. When maximum temperature is reached, valve automatically closes and can be screwed down to prevent any subsequent admission of air. Fully illustrated. LM(10b)

**Modern Methods of Annealing Gray and Malleable Cast Iron (Neuzeitliches Glühen von Grau und Temperguss).** R. Stotz. *Giesserei*, Vol. 16, Dec. 27, 1929, pages 1209–1220.

Deals with use of alloy annealing pots, preparation and packing of annealing ores and other packing materials, gas and coal dust firing for ordinary and tunnel kilns, ideal annealing curves for gray and malleable cast iron. (10b)

**Carbide Disintegration Occurring on Annealing Malleable Cast Iron (Ueber den Karbidzerfall beim Glühen von Temperguss).** E. Schuez. *Giesserei*, Vol. 16, Dec. 20, 1929, pages 1185–1189.

The author discusses the theoretical considerations in the annealing of white castings for the decomposition of the combined carbon as in the black heart malleable process. He shows that high carbon and low silicon (white heart) require a longer annealing period than low carbon, high silicon (black heart) to decompose the carbide, while increasing sulphur requires a longer annealing for both types. High carbon gives a small number of large temper carbon nodules. Low carbon and sulphur result in finely divided temper carbon, while high carbon gives balled-up temper carbon. The relative fineness or coarseness of the carbide in the white iron structure has no influence on the size of the temper carbon nodules. High annealing temperature gives a large number of fine temper carbon nodules. The structural changes taking place from solidification of the white iron to the final annealed casting are described and illustrated graphically. (10b)

**Single-Sheet or Thin-Pack Normalising, or Heat Treatment versus Box-annealing of Sheets.** R. Whitfield. *Journal Iron & Steel Institute*, May 1930, *Advance Copy* 13, 16 pages; *Engineering*, Vol. 129, May 2, 1930, pages 583–584; *Iron & Coal Trades Review*, Vol. 120, May 2, 1930, page 714.

The author points out that the demand for sheets having deep drawing possibilities has risen phenomenally due to the motor car industry, and box annealing has failed to produce such sheets by normal methods, although the mass production of high-class sheets has received careful metallurgical examination, and practical means have been devised for achieving the improved results known to be obtainable from a consideration of the equilibrium diagram. Annealing in a box-furnace offered only a partial solution, leaving the most important demands unsatisfied; practical difficulties prevented the attainment of the desired metallurgical results. Modern artistic designs demand a high-quality sheet, having deep-drawing possibilities. The normalized or sorbitic sheet fulfils all the requirements. The solution of the problem lies in single-sheet or thin-pack heat treatment, consisting of a careful preheating, soaking, and cooling—all controllable factors, unobtainable in a box-furnace. This method enables the necessary temperature to be easily reached and controlled, and by reason of the quick cooling the fine structure and physical results are maintained uniformly across the sheet. The modern normalizing furnace is a practical machine, very adaptable for the production of sheets to any specification, especially where box-annealing has failed. It is suggested that other branches of the sheet metal trade may utilize this process to advantage. LM & AEH(10b)

### Case Hardening & Nitrogen Hardening (10c)

**Changes in Quenched Steel upon Tempering.** S. Sato. *Science Reports, Tohoku Imperial University*, Vol. 18, Oct. 1929, pages 303–316; *Iron Age*, Vol. 125, Mar. 6, 1930, page 718.

In 12 steels ranging from 0.20 to 1.8% carbon change points are noted as follows:

| Temp. ° C. | Heat Evolution | Volume Change | Magnetic Change | Electric Resistance |
|---|---|---|---|---|
| 150 | slight | none | increase | decrease |
| 280 | great | contraction if retained austenite is present | decrease | decrease |
| 370 | slight | contraction | increase | ..... |
| 500 | very slight | none | ..... | ..... |

VSP(10c)

**Nitrided Nitralloy.** *Industrial Bulletin Arthur D. Little Co.*, Jan. 1930, page 1.

Describes these special steels and gives several applications. MLM(10c)

**Hardening Steel with Ammonia.** V. O. Homerberg. *Iron Age*, Vol. 123, June 27, 1929, page 1759–1761.

In the operation of case-hardening by nitrogen it is frequently necessary to protect certain portions of the article under treatment from the action of the ammonia gas. Nickel plating, to a depth of at least 0.0005 inch, has proved very satisfactory for this purpose. (10c)

**Tempering Changes in Steels.** R. Hay & R. Higgins. *Journal Royal Technical College*, Vol. 2, Jan. 1929, Part 1, pages 73–80.

The tempering of martensitic steels with increasing temperature has been found to give property-temperature curves of the form represented by the equation $y_t = y_0 e^{-\alpha t}$, where $y_t$ = property at the temperature $t$, $y_0$ is the initial property value in the martensitic state, and $\alpha$ is a constant. A classification of iron alloys has been suggested based on the thermodynamic equation $-\Delta T = RT^2(x_1 - x_2)/L$ where $x_1$ = concentration of the solute in the high temperature phase, and $x_2$ = the concentration of the solute in the low temperature phase, and R, T and L have the usual significance. By this method 2 classes of solutes are obtained, namely, those which lower the delta-gamma transformation and raise the gamma-alpha transformation, such as Si, Cr, V, Mo, W, etc., and those which act in the opposite manner by raising the delta-gamma change and lower the gamma-alpha change, such as C, Ni, Cu and Al. The significance of this method is discussed with special reference to the iron–carbon system, and it is pointed out that the eutectoid point is merely the intersection of the line representing the change in the solubility of iron carbide in gamma iron with the line representing the depression of the $A_3$ point by carbon. (10c)

**Nitralloy in the Automotive Industry.** Hilton G. Freeland. (Ludlum Steel Co.) *Journal Society Automotive Engineers*, Vol. 26, May 1930, pages 612–617.

This paper presents the constitution of the metal and its properties before and after nitriding. Procedures and precautions necessary in heat treating, machining and nitriding are explained. Methods are given for controlling the hardness and depth of case and for local protection against nitriding, and the time required for treating representative parts is stated. Includes discussion. (10c)

### Aging (10f)

**Aging of Materials. (Die Aelterung der Werkstoffe.)** A. Krüger. *Archiv für Eisenhüttenwesen*, Vol. 3, May 1930, pages 721–730; *Stahl und Eisen*, Vol. 50, May 29, 1930, page 768.

The influence of heat treatment, preceding deformation, aging time and temperature, natural and artificial aging was studied on boiler sheets with low, medium and high phosphorous content, two straight carbon steels and two silicon steels (0.80% Si, and 1.43% Si respectively). The notch toughness of these materials was investigated after a 10% deformation and various processes of aging for temperatures between −80 to +300° C. A sensitivity for aging of zinc and brass (56% Cu) could not be found for cold deformation up to 2.5%. New forms of aging structures were detected in the microstructure of aged samples. GN(10f)

**Aging Tests with Cast Steel. (Aelterungsversuche an Stahlguss.)** A. Pomp. *Stahl und Eisen*, Vol. 50, April 3, 1930, pages 440–441.

The notch toughness of 4 different carbon cast steels (C 0.11–0.27, Si 0.13–0.46, Mn 0.45–1.37, P 0.059–0.06 and S 0.034–0.040) were tested after compressing the samples from 7–10% and aging for 1 hour at 250° C. The notch toughness was tested at +20° C., 0° C., −10° C. and −20° C., and compared with non-aged samples. The notch toughness of all 4 steels tested decreased after aging. Improved cast steel lost much more in notch toughness than steels only annealed. GN(10f)

**Age Hardening of Copper Steels. (Ueber die Anlasshärtung kupferlegierten Stahles.)** H. Buchholtz & W. Köster. (Vereinigte Stahlwerke A.G. Dortmund.) *Stahl und Eisen*, Vol. 50, May 15, 1930, pages 687–695.

Paper before the Annual Meeting of the Verein deutscher Eisenhüttenleute, May 17, 1930, Düsseldorf. The hardness of copper steels with more than 0.5% Cu increases in annealing at 500° C. It is proved by measuring the changes of electrical, magnetic and physical properties in relation to the preceding heat treatment that the observed aging effect is due to a precipitation of copper in the supersaturated $\alpha$-iron. The precipitation of copper and the spheroidization of the precipitated particles proceeds slowly. The precipitation of copper in copper steels, therefore, is much like the decomposition of other $\alpha$-iron solid solutions. The solubility of copper in $\alpha$-Fe amounts to 0.4% at room temperature, and increases with increasing temperature giving at 810° C., which is the temperature of the eutectoid transformation, a solubility of 3.4%. In steels supersaturated in carbon as well as copper both elements are precipitated independently from each other. In cooling down from $\alpha$-solid solution a supersaturated $\alpha$-solid solution is formed containing more than the highest possible amount of 3.4% Cu. The described age hardening effect results in an improvement of the physical properties; yield point, tensile strength and fatigue strength are increased without impairing the values representing the properties of plasticity. The properties of age hardened chromium-copper steel forgings are the same as those of improved chromium-nickel steels up to about 70 kg./mm.² (99,400 lbs./in.²) tensile strength. Chromium-copper steel forgings are distinguished by a high uniformity of properties even for large cross-sections. Copper steel is also after the aging process rather stable for aging. The yield point at elevated temperatures and the fatigue strength are increased by the aging process. GN(10f)

**Contribution to the Problem of Age Hardening of Iron. (Ein Beitrag zur Frage des Ausscheidungshärte des Eisens.)** W. Eilender & R. Wasmuht. *Archiv für Eisenhüttenwesen*, Vol. 3, April 1930, pages 659–664; *Stahl und Eisen*, Vol. 50, May 9, 1930, pages 632.

Concluding from the small amount of solubility of carbon in $\alpha$-Fe the author states that age hardening, as results from this solubility can be expected for N and O, in considering the binary systems iron–nitrogen and iron–oxygen. After melting Armco iron with 0.014% C, 0.02% Mn, 0.007% P, 0.06% Cu, and traces of silicon in a high frequency furnace, increasing amounts of nitrogen and oxygen were introduced. Samples from those melts were exposed to an aging process by quenching from 680° in ice water and determining the hardness at room temperature after various times of aging. The oxygen content has no essential bearing on the aging hardness. The influence of nitrogen is different. The given hardness-time curves indicate that the age hardness is not essentially influenced by nitrogen contents up to 0.01%. Above 0.015% nitrogen the increase of hardness by aging is remarkable and amounted to 14% for 0.01% N, to 70% for 0.04% N. The influence of nitrogen contents still higher was studied with nitrided steels. Samples from 0.4% up to 0.9% N indicated a further increase of the age hardness. The age hardness in relation to the aging time was studied. The highest increase of hardness was obtained for oxygen as well as nitrogen samples on aging at room temperature. Thirty-two common open hearth and Bessemer steels were examined. No age hardening was observed in these steels which contained up to 0.017% N and 0.015 $O_2$. GN(10f)

## JOINING OF METALS & ALLOYS (11)

### Soldering (11b)

**Soft Solder and Joints.** *Electrician*, May 9, 1930, page 586.

An abstract. Part 1 of a Report of the British Non-ferrous Metals Research Association on the Jointing of Metals deals with soft solders and soldered joints. The report is illustrated with photomicrographs and diagrams. Chapter headings are: (1) Soft Solder Alloys, (2) Physical Properties of the Solder Alloys, (3) Strength (Shear) of Soldered Joints, (4) Metallurgy of a Soldered Joint, (5) Corrosion Resistance of the Solder Alloys, and (6) Some Practical Considerations. With respect to electrical resistivity and conductivity it is stated that within the limits of compositions studied, the presence of antimony causes an increase in electric resistivity—more marked in the absence of lead. In lead-tin-antimony alloys the maximum resistivity occurs when the limit of solid solubility of antimony (in tin) is reached. Tin shows the minimum resistivity, lead the maximum. Lead has little effect on tin and tin-antimony alloys until the proportion of lead exceeds that required for the alloy to be wholly eutectic in constitution. Of graded solders "A" shows the lowest resistivity and "D" the highest. Attention is drawn to the alloys of tin and antimony. Antimony reduces the electrical conductivity, somewhat, of tin but up to 6% the conductivity is maintained sensibly the same as the best tin-lead solder. Experiments indicate that for stator and rotor end connectors in induction motors that the presence of antimony in solder would not increase the resistance of a stator or a rotor by more than 0.8%. The presence of antimony does not cause the increase in resistance of a joint with temperature to be appreciably greater, which is important in the added shearing strength it gives to the alloy. It retains its strength to a point 40–50°C. higher in the temperature scale than any lead-containing solder, making it very desirable for jointing of armature conductors to commutator necks. For maximum effect preliminary tinning must be done with pure tin or antimony-tin. WHB(11b)

**Modern Solders and Their Applications.** Wm. Mason. *Chemical Engineering & Mining Review*, Feb. 15, 1930, Vol 22, pages 189–190.

The views of several recognized authorities and makers of solders are given, with no details included, which have not been carried out in practice. In most cases 25% Sn is sufficient. A solder containing 15% Cd was found equal to one with 20% Sn, except in the case of galvanized iron. Goldschmidt solder containing 12% Cd and 2% Sn and melting at 220–240° C. was found satisfactory for soldering Zn articles, electrical apparatus and for caps of fuses. This solder flows better than many solders and is used also for speaking tubes. Fe, Pb, lead-coated sheet iron and tin plate can be successfully joined with a lead-solder containing 10–13% of Sb. For galvanized iron the Zn had to be removed with HCl and the seat of the joint coated with a preliminary layer of the antimony solder. A solder consisting of Hg 4%, Sn 3% and Pb 93% has worked, without cleaning, save brushing with the fluxing liquor, on welding galvanized sheet iron and sheet Zn, Cu and brass. Other solders contained 6% Hg and 3% Sn, and the other 8% Hg and 6% Sn. Compressed air pipes jointed with this alloy stood pressures up to 170 atmospheres and the low melting point (180–260° C.) eliminates any danger of Hg fumes. This solder has been extensively used for ship fittings. WHB(11b)

### Welding & Cutting (11c)

**Welding Practices in Big Tank Shop.** E. E. Thum. *Iron Age*, Mar. 6, 1930, Vol 125, pages 715–718.

Discusses problems encountered by the Baldwin Locomotive Works, and how they were solved. Two holes are punched in plate and bar, and drawn together with erection bolts. After required welding, bolts are removed and holes plugged with filler metal. Temporary fitting-up bolts welded on are best substitutes for part of the open holes. After welding, strong-backs are removed and bolts cut away. Similar long angle-iron strong-backs are useful in erecting tanks. All exposed welds on flat plates, such as butt seams and plug welds are ground smooth. Foundation coat of paint is sprayed on. Thin putty is worked into depressions and pits. VSP(11c)

**Welding of Metals. (Ueber das Schweissen der Metalle.)** Hans Neese. *Metallwirtschaft*, April 4, 1930, Vol. 9, No. 14, pages 297–300.

A review covering the welding and brazing of brass, bronze, copper, aluminum, nickel and monel, gives complete information on methods, welding rods, fluxes, temperatures, preliminary cleaning and physical properties obtained. CEM(11c)

**Welding Repairs.** *Oxy-Acetylene Tips*, Vol. 8, May 1930, pages 219, 221–223, 227.

Articles describe the repair of a truck housing, casting defect in a rotary pump, broken locomotive steam cylinder, clay products pulverizer arm and acetic acid still and coils. (11c)

**The Growing Importance of Arc Welding in Industry.** *The Digest*, Vol. 10, June 1930, pages 27–32.

Arc Welding is coming to the fore in the manufacture of tanks and pressure vessels. Pipes are welded, thus saving pipe fittings, and many jigs and fixtures are built up from small pieces of steel that formerly went to the scrap pile. MLM(11c)

**The Strength and Design of Fusion Welds for Unfired Pressure Vessels.** L. W. Schuster. *Engineering*, Vol. 129, March 14, 1930, pages 362–364; March 21, 1930, pages 394–396; March 28, 1930, pages 427–428; *Engineer*, Vol. 149, March 14, 1930, page 308; *Journal American Welding Society*, Vol. 9, May 1930, pages 18–64; *Iron Age*, Vol. 125, April 17, 1930, page 1143.

Condensed from paper read before the Institution of Mechanical Engineers, March 7, 1930. Various mechanical tests were carried out on welds in mild steel with a limited number of tests on other materials used for pressure vessels. Metallurgical examination was made to find causes of variable properties of welds. Strengths of various forms of joints used on pressure vessels were determined attempting to classify them on an efficiency basis. VSP & LM(11c)

**The Future of Automatic Arc Welding in the Boiler Industry.** G. H Koch. (Westinghouse Elec. & Mfg. Co.) *Paper, Master Boilermakers Association Convention*, Pittsburgh, Pa., May 20–23, 1930.

This paper points out the limitations of riveting as a result of increasing plate thicknesses to meet the demand for higher plant efficiencies reflected in larger boilers and higher steam pressures. He predicts the application of welding to boiler manufacture in parallel with its use for the manufacture of oil cracking stills, etc. Paper concludes with the description of automatic welding machines, and the methods now in use in other industries. (11c)

**The Welding of Aluminum. (Ueber das Schweissen von Aluminium.)** *Zeitschrift Verein deutscher Ingenieure*, Vol. 74, Feb. 22, 1930, pages 251–252.

Holler reviews and discusses a few methods of joining aluminum parts by welding: (1) the hammer-welding process of Heraeus which requires great care in the observation of the proper temperature and gives very high-grade joints; (2) for less accessible parts gas-welding whereby the parts are heated to melting which also requires maintenance of proper temperature; (3) electric arc-welding, little used on account of high arc temperature and difficulty of regulation; (4) electric resistance-welding where the parts to be joined form the resistance in an electric circuit; this method lends itself best for regulation and control of cooling. Ha(11c)

**Fusion Welding Regulations.** *Engineering*, Vol. 129, March 21, 1930, page 382.

Editorial commenting on paper by L. W. Schuster "The Strength and Design of Fusion Welds for Unfired Pressure Vessels" read before the Institution of Mechanical Engineers, March 7, 1930. Praises Institution for recommending formation of committee to standardize method of welding suitable for pressure vessels to insure same safety in their use as that obtained with riveting. LM(11c)

**Shape-Cut Steel.** *Oxy-Acetylene Tips*, Vol. 8, May 1930, pages 229–233a

Automatic oxy-acetylene shape cutting speeds up production and cuts cost of machinery and metal products. (11c)

**Design for Oxwelded Piping.** *Oxy-Acetylene Tips*, Vol. 8, May 1930. pages 224–226.

Standard specifications for various types of line joints. (11c)

**Arc Welding at a Large Boiler Works.** *Engineer*, Vol. 149, March 28, 1930, pages 344–345.

Gives particulars of an English Electric Company welding installation made in the Bradley Engineering Works, Bilston. Fully illustrated. LM(11c)

**Applying the Principles of Steel Mill Practice to Arc Welding.** J. B. Austin. *Iron & Steel Engineer*, Vol. 7, June 1930, pages 319–24.

A low-carbon steel base rod is given a uniform coating of alloy ingredients carefully controlled as to weight for making alloy steels as applied to high-manganese steel alloy. When an arc is struck, the coating dissolves into the globule of molten metal which forms at the tip of the electrode. The use of a low-carbon base rod and a heavy alloy coating affords additional advantages. The heavy refractory coating on the electrode concentrates the heat at the electrode tip, permitting the use of a lower current. An alloy electrode does not display the same degree of arc stability as a low-carbon steel electrode. While greater arc stability and greater ease and speed of welding have been provided for the operator in the coated electrode, the personal skill of the operator must be good for ultimate success. An arc welding tool has recently been perfected which removes a large part of the personal skill required. The arc welding applications referred to emphasize the analogy between mill practice and the arc welders' method of alloying and purifying metals in the arc. WHB(11c)

**Welded Steel Floor Construction.** Lee H. Miller. (American Institute of Steel Construction, Inc.) *Journal American Welding Society*, Vol. 9, May 1930, pages 11–17; *Discussion*, July 1930, pages 60-64.

Gives advantages of using welded floor construction. Used in connection with multiple story buildings, it is possible to add 25% more floors to the structure without increasing the load on the foundations. Floors already constructed show results confirming theoretical analysis as to strength and deflection. LM(11c)

**Welded Automobile Bodies and the Oxy-Acetylene Torch.** Joseph W. Meadowcroft. (Edward G. Budd Manufacturing Co.) *American Machinist*, Vol. 72, Mar. 27, 1930, pages 521.

Discusses the uses and value of the oxy-acetylene torch for this type of work. See *Metals & Alloys*, June 1930, page 567. RHP(11c)

**Some Applications of Welding to Steel Structure.** H. Penn. (American Institute of Steel Construction.) *Engineering & Contracting*, Vol. 64, May 1930, pages 207–208.

Welding can be used in connection with riveted construction so that the greatest economy may result in the product. GN(11c)

**Tunnel Lining of Welded Steel.** S. A. Thoresen. (Parson, Klapp Brinckerhoff & Douglas). *Iron Age*, Vol. 125, April 3, 1930, pages 985–989.

Describes Detroit-Windsor vehicular tunnel, lined with structural steel instead of segments of heavy cast iron. Structural steel lining was used because it fulfilled all demands and met conditions peculiar to the characteristics of Detroit clay. The steel in the primary lining was designed to carry a compressive stress of 14,000 lbs./in.$^2$; leaving the surplus strength of steel available for possible distortion. Pressed steel fabricated by electric arc welding was used for the lining. Steel being a mild open-hearth of pressing quality. Skin plates were formed cold from a blank approximately 4 ft. × 9 ft. × $^3/_8$ in., sheared accurately. This blank was doped with lubricating compound, turned over and fed into forming die. All details of manufacture of these segments were carefully watched and constantly checked. In conclusion summarizes advantages and future developments. VSP(11c)

**Procedure Control in Aircraft Welding.** H. L. Whittemore, J. J. Crowe & H. H. Moss. In *Preprint* No. 33, *Symposium on Aircraft Materials*, June 1930 Meeting, *American Society for Testing Materials*, 7 pages.

In order to minimize the danger of unsound welds due to the human element in hand-welding, procedure control is advocated. Tests of welded joints in tubular members for aircraft, all made by one particular welder, were uniformly good. It is thought that by sufficiently extensive procedure control, specifying every step, with nothing left to the discretion of the operator, and inspectors to watch the welders, welded structures of uniformly high quality can be produced, if the human element is reduced to the absolute minimum. HWG(11c)

**Building an All Welded Oil Storage Tank by Arc Welding.** I. S. Dmitrieff. *Journal American Welding Society*, Vol. 9, May 1930, pages 64–70.

Describes method used by The Research Laboratory for Welding of the Far-Eastern State University at Vladivostok for building a benzine storage tank. LFM(11c)

**The First Arc-Welded Bridge in Europe.** Stefan Bryla. (Professor of the Technical University, Lwow, Poland.) *Journal American Welding Society*, Vol. 9, May 1930, pages 71–75.

Fully illustrated article describing bridge erected for the Polish government in Lowicz, Poland. LFM(11c)

**Design for Oxy-Acetylene Welded Piping.** R. W. Boggs. (Oxweld Acetylene Co.) *Journal American Welding Society*, Vol. 9, May 1930, pages 97–102.

Summarizes design recommendations for oxy-acetylene welded line joints in steel and wrought iron pipe. Gives designs for various types of butt welds and for special reinforced welded butt joints. LFM(11c)

**Arc Welded Steel Structures in America.** *Engineer*, Vol. 149, June 13, 1930, page 668.

From remarks on progress of arc welding made by F. P. McKibben, April 27, 1930, on the occasion when the first weld was made in the building of the Edison Illuminating Company, Boston. LFM(11c)

**The Needs of the Metropolitan District for Instruction in Welding.** W. F. McKay (International Oxygen Company.) *Journal American Welding Society*, Vol. 9, May 1930, pages 75–79; *Discussion*, July 1930, pages 72-76.

Brief discussion. LFM(11c)

**Production Welding.** DeW. Endicott. (Union Carbide Company.) *Journal American Welding Society*, Vol. 9, May 1930, pages 80–97.

Well illustrated article showing how oxy-acetylene welding process has become a recognized, universal production tool. LFM(11c)

**The Application of Oxy-Acetylene Welding to Rotary Kiln Construction.** H. E. Rockefeller. (Linde Air Products Company.) *Journal American Welding Society*, Vol. 9, May 1930, pages 102–109; *Discussion*, July 1930, pages 13-15.

Comparison of welded and riveted construction of kilns and similar containers. Shows advantages of using oxwelded joint for this type of construction. LFM(11c)

# WORKING OF METALS & ALLOYS (12)

## Melting & Refining (12a)

**Melting of Dense Brass Castings. Defects and the Results. (Erschmelzen von dichtem Messingguss. Fehler und deren Folgen.)** M. SCHIED. *Giesserei Zeitung*, June 1, 1930, pages 301–304.

For obtaining a satisfactory and dense brass casting, the raw material should be inspected as to its usefulness before it reaches the crucible. Raw material containing tin and aluminum must be eliminated. Likewise stamping scrap must be eliminated from drawn brass. Only a reliable covering material should be used for the molten bath and this should be placed in the bottom of the crucible before the raw material is introduced. When the melting furnace is provided with a preheater, the preheater should not be filled until there is a certain quantity of the melt in the crucible. The raw material which is introduced into the preheater must in no case be in a molten condition. The brass must not be allowed to reach the boiling point. As soon as an iron rod inserted in it begins to vibrate, the brass is good. When this stage is reached it should be removed from the furnace, and never left there longer than necessary. No deoxidizing agent other than phosphor-copper should be used. When this is introduced, care must be taken to see that the molten brass is stirred, if the deoxidizing agent is to be fully effective. Finally all slag must be carefully removed before the brass is poured into the molds. AJM(12a)

**Melting Practice for Three Types of Basic Electric Steel.** H. P. RASSBACH. (Midvale Co.) *Transactions American Society for Steel Treating*, Vol. 17, April 1930, pages 570–585.

Paper presented before the 11th Annual Convention of the Society, Sept. 1929. Includes discussion. See *Metals & Alloys*, Jan. 1930, page 344. WLC(12a)

**Practice in Making Duplex Steel.** J. E. CARLIN. *Iron Age*, Vol. 125, March 27, 1930, pages 925–927.

This process combines the rapidity of acid Bessemer with the dephosphorizing power of basic open-hearth. It is carried out usually in a tilting Talbot furnace of 100 to 300 tons capacity. Slag differs from that of regular basic process. The elimination of P is carried out according to the following reactions:

$$2P + 8FeO \rightleftharpoons Fe_3P_2O_8 + 5Fe$$

$$Fe_3P_2O_8 + 3CaO \rightleftharpoons Ca_3P_2O_8 + 3FeO$$

The algebraic sum of reactions 1 and 2 gives reaction

$$2P + 5FeO + 3CaO \rightleftharpoons Ca_3P_2O_8 + 5Fe$$

The charge is completely molten and consists of duplex metal followed by about 10–20% of its weight of pig iron. Duplex metal is produced from either basic or Bessemer pig iron. In the basic process, iron-oxide in the form of iron ore is used to oxidize excess C, while in duplex process an excess of C in molten pig iron is used. Ideal finishing conditions include—Equilibrium between slag and metal with respect to iron oxide; Judicious use of Si and Mn, Tapping technique which will provide ladleful of steel before the slag comes; Minimum amount of slag covering the metal in the ladle; Dilution of ferrous oxides; Temperature high enough to warrant holding heat in the ladle. VSP(12a)

## Casting & Solidification (12b)

**On the Formation of Graphite During the Solidification of Cast Iron.** TUTOM KASE. *Science Reports Tôhoku Imperical University*, Vol. 19, March 1930, pages 18–34.

Various suggested explanations of the process of the formation of graphite in cast iron have not yet been satisfactorily solved. The present writer has once more investigated this problem, and experiments have been made to determine the change of electric resistance in the vicinity of the eutectic temperature, and also to make the thermal analysis, and the microscopic observation of cast iron when cooled under various conditions. In conclusion he finds that the adoption of the so-called double diagram is untenable. (12b)

## Machining (12g)

**The Use of Tungsten Carbide as a Cutting Material on Heavy Machine Tools.** C. SELLERS. (William Sellers Co.) *Mechanical Engineering*, Vol. 52, July 1930, pages 683–689.

The author briefly reviews early experience with tungsten carbide tools, discusses the grinding problem and stresses the importance of correct grinding, clearance angles and shape of tools. The types of tools are described and commented upon. The difficulties and remedies in each case are listed. Six typical successful applications are described. Advantages and disadvantages of tungsten carbide tools are briefly discussed. GN(12g)

**Cutting with Carbide Tools.** OWEN K. PARMITER. (Firth-Sterling Steel Co.) *Iron Age*, Vol. 125, Mar. 20, 1930, pages 863–864, 906; *Iron Trade Review*, Vol. 86, Apr. 24, 1930, pages 71–74.

Part of address on "High production steels" delivered before the New Jersey chapter of the American Society for Steel Treating, Mar. 11. The mono-carbide (WC), is the principal constituent of the new cutting tool. It is made from very pure and finely powdered metallic W mixed with proper amount of lampblack or some other suitable form of C. The mixture is exposed under an atmosphere of H to a high heat for a predetermined period of time. The resulting carbide powder is mixed with proper amount of Co powder of equal fineness. Resulting product is worked for hours in a ball mill. Compacting is done by pressing the powder in dies under hydraulic pressure. Prepared WC shows a hardness value in excess of 1500 Brinell which is more than double that of the hardest steel. WC is applied to cutting tools by inserting a small chip on a holder of a cheaper material, usually some form of tool steel. Most recent development of applying the carbide to cutting tools is that of the "mechanically held" tip. Grinding WC is done with silicon carbide wheels. Rakes and clearance angles for general use of cemented WC:

| Material | Front Clearance | Side Clearance | Top Side Slope | Lip Radius |
|---|---|---|---|---|
| Cast Iron | 6° | 4° | 3° | ..... |
| Soft Steel | 6° | 6° | 12° | 3/8–1 1/4 in. |
| Medium Steel | 6° | 6° | 14° | 3/8–1 1/4 in. |
| Hard Steel | 4° | 4° | 14° | 5/8–1 in. |
| Non-Ferrous Metals | 6° | 6° | 10–20° | 4–14°* |
| Molded composited (non-metallic) | 4–6° | 4–6° | 8–12° | 6–10°* |

* Top Back Slope.

Cemented WC may also be used for drawing dies in general, and especially those used in drawing wire. VSP(12g)

**Precautions in Applying "Widia." (Ueber Hilfsmittel bei der Einführung und Anwendung des Werkzeugmetals "Widia".)** E. LANZ. *Krupp'sche Monatshefte*, Vol. 11, May 1930, pages 99–100.

The article stresses the precautions to be taken in applying "Widia," points to careful centralized supervision of the tools and deals with the brazing of the "Widia" tips to the tool shaft and the grinding of the tools. GN(12g)

## Pickling (12i)

**Modern Mechanical Pickling.** *Iron & Coal Trades Review*, Vol. 120, April 25, 1930, page 684.

Description of recent British equipment. Craven Brothers (Manchester), Ltd. have recently installed ten pickling machines, each with a capacity of 48–50 tons of medium gage, 10 foot sheets each 24 hours. Four men now do work equivalent to 14 with the old hand pickling equipment. RHP(12i)

## Cold Working (12j)

**On the Distribution of Hardness by Cold Working.** W. P. SYKES (Cleveland Wire Works, General Electric Co.) & A. C. ELLSWORTH (Thompson, Products Co.). *Transactions American Society for Steel Treating*, Vol. 17 April 1930, pages 509–525.

Paper presented before the 11th Annual Convention of American Society for Steel Treating, Sept. 1929. Includes discussion. See *Metals & Alloys* Jan. 1930, page 344. WLC(12j)

**Effect of Cold Work on Steel.** F. S. MERRILLS. *Iron & Coal Trades Review*, Vol. 120, Feb. 28, 1930, page 367.

Abstract of a paper entitled "Effects of Cold Work on the Physical Properties of Steel" which was read before the Sheffield Metallurgical Association, Feb. 11, 1930. A metal strained or cold worked in any way is at once possessed of different physical properties. Elongation is lower in cold worked material. Heat treatment of a material to be cold worked must be varied to suit the requirements of the finished product. Effects of cold working are not permanent at ordinary temperatures though some steels retain the internal stresses longer than others. Rate at which the change occurs in aging varies with the method of cold working and the composition of the steel. Aging for a period of a year brings a rolled wire into the same condition as that of a drawn wire. Heating of the rolled wire to the temperature of boiling water for a few minutes has the same effect as aging for a year. The bend test alone does not give an indication of the capability of a wire to withstand fatigue, except under the conditions under which the bending is done. A consistently good bend test, only indicates that the heat treatment has been properly carried out. It also indicates a drastically-overdrawn wire. RHP(12j)

**Note on Thread Rolling.** H. S. ROWELL. *Engineering*, Vol. 129, June 6, 1930, pages 721–722.

Thread rolling is becoming increasingly used in screws of the highest accuracy. The diameter of the blank governs the dimensions of the screw so it is of extreme importance that the blank diameter be correct. Gives equations for calculating correct blank diameter. LFM(12j)

## Cleaning (12k)

**Pre-Finishing Treatments for Metal Surfaces.** *American Machinist*, Vol. 72, Mar. 13, 1930, page 423.

Good cleaning is essential for success in enameling, japanning or similarly coating a metal surface. Impurities which adhere to the surface may be burned off, chemically removed with either an acid or an alkali solution, absorbed by a volatile oil such as naphtha or gasoline, buffed off, or removed by sandblasting. The method used will vary according to the type of material to be cleaned as well as material which is to be removed. RHP(12k)

# DEFECTS (13)

**The Notch-Danger. (Ueber die Kerbgefahr.)** W. KUNTZE. *Zeitschrift Verein deutscher Ingenieure*, Vol. 74, Jan. 18, 1930, pages 78–82.

Report of the Staatliche Materialprüfungsamt. Experiments on the safety of notched pieces of material find very intense interest because the question of notching has not yet been solved satisfactorily in theory nor practice. The widely spread view that the elastic increase of tension occurring in the notch under tensile stress reduces the strength of technologically brittle materials is refuted in the present investigation. It is proved that bending influences, even though they be very small and occur unexpectedly, form the source of danger. Since accurate bases of calculation are, so far, lacking special emphasis must be laid on qualities which can be designated more correctly as structure and strength against separation than, as in the usual manner, by tensile strength and elongation. Ha(13)

**Causes of Defects in Copper Wire.** H. C. JENNISON. (American Brass Co.) *Iron Age*, Vol. 125, Mar. 13, 1930, pages 792–793.

From a paper read before the American Institute of Mining & Metallurgical Engineers, Feb. 19, 1930. See *Metals & Alloys*, June 1930, page 569. VSP(13)

**Failures of Aircraft Engine Parts and Causes Thereof.** T. T. MCNEILL. In *Preprint* No. 33, *Symposium on Aircraft Materials*, June 1930 Meeting, *American Society for Testing Materials*, 10 pages.

Illustrated account of spring, valve, piston, connecting rod, crank shaft, bearing and other failures of aircraft engines met in type testing at the Bureau of Standards. In general, design rather than materials account for the failures. Poor finish, stamped numbers, key ways with sharp corners and more rarely seams or dirty steel, account for many fatigue failures. Poor bonding of babbit to bronze bearings is a common cause of failure. HWG(13)

# CHEMICAL ANALYSIS (14)

**A Study of the Quantitative Precipitation of Calcium Oxalate in the Presence of the Phosphate Ion.** J. T. DOBBINS & W. M. MEBANE. *Journal American Chemical Society*, Vol. 52, April 1930, pages 1469–1472.

Accurate results were obtained by the following procedure: solution is made alkaline with ammonium hydroxide and 5 cc. concentrated added. Excess of ammonium oxalate is added at room temperature, stirred and the precipitate allowed to stand for at least an hour. The precipitate is filtered off, washed with water containing a small amount of ammonia, transferred with paper to the precipitation beaker, dissolved in dilute sulphuric and titrated with 0.1 N potassium permanganate. MEH(14)

**The Volumetric Estimation of Sodium.** EARLE R. CALEY. *Journal American Chemical Society*, Vol. 52, April 1930, pages 1349–1353.

Claimed to be rapid, the method is based upon the precipitation as sodium magnesium uranyl acetate and the titration of the uranium content of the precipitate by means of a standard phosphate solution. Advantages are: sodium may be determined in presence of small amounts of phosphates without their preliminary removal; there is no need to free the original solution from insoluble or inert suspended matter. MEH(14)

**On the Influence of Lead on the Titration of Antimony with Permanganate in the Analysis of White-metals. (Ueber den Einfluss des Bleis auf die Titration des Antimons mit Permanganat bei der Analyse von Weissmetallen.)** A. WASSIFIEFF & H. STUTZER. *Zeitschrift für Analytische Chemie*, April 10, 1929, pages 97–102.

For the determination of antimony in white-bearing metals the method of dissolving the alloy in concentrated $H_2SO_4$ is particularly useful because Sb alone of all compounds goes into the solution in the lowest state of oxidation so that it can be titrated. The method is described and discussed in detail; as special convenience is mentioned that the actual percentages are obtained without any correction. Ha(14)

**Rapid Volumetric Tin Determination in Genuine Babbitts.** JAMES SILBERSTEIN. *Chemist-Analyst*, Vol. 19, May 1930, page 14.

Cu must be removed before the titration of Sn with iodine if present over 3%. Dissolve sample in $H_2SO_4$ and titrate Sb with $KMnO_4$. Add a half teaspoonful of red phosphorus, boil 15 min., filter and wash with dilute $H_2SO_4$. Copper phosphide is precipitated. Add HCl and Ni strip to solution, reduce and titrate Sn with iodine and starch indicator.

CEM(14)

**Determination of Manganese in Steel and Iron by the Persulphate-Arsenite Method.** H. A. BRIGHT & C. P. LARABEE. *Bureau of Standards Journal of Research*, Oct. 1929, pages 573–579.

The advantage of using phosphoric acid in the persulphate-arsenite method and the effect of certain dissolved salts on the titration of permanganic acid by sodium arsenite are discussed. A description is given of the persulphate-arsenite method as used at the Bureau of Standards. In the recommended procedure, which embodies no new principles, as much as 20 mg. of manganese can be handled. It is, therefore, possible to use 1 g. samples in practically all cases. The results obtained by this procedure are much better than those obtained on smaller samples by the ordinary persulphate method and are practically of the same order of accuracy as obtained by the standard and much more elaborate bismuthate method.

(14)

**Distillation-Amalgamation Methods for the Technical Determination of Mercury in Ores.** C. W. DAVIS. *Information Circular* 6202, *United States Bureau of Mines*, 1929, 8 pages.

(Contains 15 footnote references.) AHE(14)

**The Determination and Separation of Rare Metals from Other Metals. XVIII. Determination of Indium and Its Separation from the Monoxides and Sesquioxides. (Die Bestimmung und Trennung seltener Metalle von anderen Metallen. XVIII. Die Bestimmung des Indiums und seine Trennung von den Monoxyden und Sesquioxyden.)** LUDWIG MOSER & FRIEDRICH SIEGMANN. *Monatshefte für Chemie*, Vol. 55, Jan. 1930, pages 14–24.

As indium occurs only as impurity, usually in sulphides, it is necessary to separate it from large quantities of other metals. In belongs to the third group. $In(OH)_3$ can be precipitated with excess $NH_4OH$, washed free from $NH_4Cl$, ignited, and weighed as $In_2O_3$. $In(OH)_3$ can also be formed by adding to the slightly acid solution KCNO until methyl orange turns yellow. To precipitate $In_2S_3$ add to a neutral solution 30 cc. 2N acetic acid, 10 cc. 2N $NH_4OH$ and pass in $H_2S$, or pass $H_2S$ into a solution which is .03–.05 N in HCl. *Separation of In from Zn.* Add enough $NH_4Cl$ to form zinc ammonium complex and precipitate In with KCNO. If more than 10 times as much Zn as In is present dissolve the impure $In(OH)_3$ in HCl, nearly neutralize and reprecipitate. *Separation of In from Ni.* Use the same procedure as for Zn but avoid an excess of KCNO, otherwise Ni will precipitate. A single precipitation gives good results even when 10 times as much Ni as In is present. *Separation of In from Co.* Nearly neutralize with $Na_2CO_3$ and add KCN until the precipitate formed redissolves. Then add 10% KCNO, boil and filter $In(OH)_3$, and ignite. If Co is more than 10 times the In content, dissolve in HCl and reprecipitate with $NH_4OH$. Co can be determined in the filtrate by electrolysis. *Separation of In from Mn.* Neutralize the solution with $NH_4OH$, add 30 cc. 2N acetic acid and 10 cc. 2N $NH_4OH$ for each 100 cc. solution, boil and pass in $H_2S$. For 10 mg. $In_2O_3$ the volume should not be over 100 cc., otherwise the $In_2S_3$ precipitate will be too dispersed. Dissolve $In_2S_3$ in HCl and reprecipitate with $NH_4OH$. *Separation of In from Al.* Add sulphosalicylic acid and neutralize with $(NH_4)_2CO_3$ using methyl orange. Acidify with acetic acid and pass in $H_2S$. Filter and wash with ammonium acetate. Dissolve and reprecipitate as above. *Separation of In from Fe.* Add $NH_4OH$ drop by drop until a slight precipitate forms. Dissolve this in dilute HCl and make solution 0.03 N with HCl. Saturate with $H_2S$ for 2 hours. Filter and wash with slightly acid $H_2S$ water. If much ferric Fe is present, reduce in acid solution with $H_2S$ at 70° C., drive out excess $H_2S$ by passing through $CO_2$, and neutralize with $NH_4OH$. Then proceed as above. *Separation of In from Cr.* Add 10% KCNO solution to the slightly acid solution until it is yellow to methyl orange. Boil and filter $In(OH)_3$. Good separation is obtained even with 500 times as much Cr as In.

CEM(14)

**The Determination of Small Amounts of Nickel in Steel.** B. JONES. *Analyst*, Vol. 54, Oct. 1929, pages 582–589.

The process involves the isolation of nickel (from iron and its alloying elements) as potassium nickel-cyanide in ammoniacal solution, the iron, chromium and manganese being precipitated as hydroxides. This gives a very clean and quantitative separation of nickel from the main constituents of steel; the author describes certain modifications required when copper and cobalt are also present. Details are given of the application of the method to carbon and alloy steels; all sections of the paper are illustrated by tabular results of a number of experimental determinations. (14)

**The Sensitivity and Applicability of the Picric Acid Test for Potassium.** EARLE R. CALEY. *Journal American Chemical Society*, Vol. 52, March 1930, pages 953–956.

It has been found that sodium interferes with this test more than has been generally supposed. However, picric acid may be employed as a confirmatory test for potassium after the approximate separation of the 2 elements or for the examination of small residues of alkali chlorides. For these purposes it is more sensitive than perchloric acid, chloroplatinic acid or tartaric acid, and while not as sensitive as sodium cobaltinitrite, it has the advantage of possessing greater stability. MEH(14)

**The Iodometric Determination of Iron.** ERNEST H. SWIFT. *Journal American Chemical Society*, Vol. 52, Sept. 1929, pages 2682–2689.

The conditions determining the reliability of the simple iodometric determination of ferric iron originally suggested by Mohr have been studied. Results show that an accuracy of 0.2% is obtained when the reaction between the ferric chloride and the iodide is allowed to take place in a closed flask for 5 minutes in about 30 ml. of solution which contains not less than 3 g. KI and from 0.25 to 25 milli-equivalents of HCl, and this solution is then diluted to about 100 ml. and titrated with thiosulphate. Permanent end-points are obtained under these conditions. When sulphuric acid is used more acid and more KI are required and the end-points are not as permanent as with HCl. MEH(14)

**The Nephelometric Analysis of Zinc.** LAWRENCE T. FAIRHALL & JOHN R. RICHARDSON. *Journal American Chemical Society*, Vol. 52, March 1930, pages 938–944.

In the analysis of biological ash for traces of zinc, the separation of the latter from certain other metals and from iron in particular is most accurately made by co-precipitation with copper as the sulphide at a pH of 3. The nephelometric estimation of zinc as the ferrocyanide gives accurate results only within definite limits of acidity and salt concentration. Suitable conditions for this have been found at pH 2.3 and at a salt concentration of 0.0268 molar with respect to potassium chloride. MEH(14)

## HISTORICAL & BIOGRAPHICAL (15)

**Progress in Iron Metallurgy.** CHARLES PAGE PERIN. (Perin & Marshall). *Iron Age*, Vol. 125, Mar. 20, 1930, page 862.

From special lecture in a series on the progress in metallurgy given at Columbia University. Traces the history of iron smelting from a clay stack common in India, where a bloom of 30 to 50 lbs. is produced, to the modern blast furnace making a ton per minute. VSP(15)

## ECONOMIC (16)

**The Lesser Iron- and Steel-Producing Countries in Europe.** *Iron & Coal Trades Review*, Vol. 120, April 18, 1930, page 641; April 25, 1930, page 675.

Review of progress and production in Russia, Czecho-Slovakia, Austria, Hungary, Poland, Italy, Sweden and Spain. These countries have made considerable advance in production. The pig-iron output of last year was 15.7% over 1928 and 25.4% over 1927. For steel the increase was 12.3% over 1928 and 30.3% over 1927. This indicates a greater percentage increase than that of the other European countries. A table gives the individual production for each country in 1927, 1928 and 1929. RHP(16)

**South African Iron and Steel Industry.** T. NIMMO DEWAR. *Iron & Coal Trades Review*, Vol. 120, April 11, 1930, pages 604–605; April 18, 1930, pages 642–643.

From a paper presented to the Third (Triennial) Empire Mining and Metallurgical Congress, South Africa, 1929. Discusses the present position and prospects from both the view of manufacture and geologic deposits. Also coal deposits in relation to the iron and steel industry. RHP(16)

**The Iron and Steel Industry Since the War.** M. S. BIRKETT. *Iron & Coal Trades Review*, Vol. 120, Mar. 21, 1930, pages 492–493; Mar. 28, 1930, 528–529; April 4, 1930, pages 560–561.

A review covering the 10 years since the war. Is largely concerned with the industry in Great Britain, but also reviews world production in general and Germany, France, Belgium and the United States more particularly.

RHP(16)

**Gold, Silver, Copper, Lead and Zinc in the Eastern States in 1928.** J. P. DUNLOP. *Mineral Resources of the United States*, 1928, Part I, *United States Bureau of Mines*, November 22, 1929, pages 21–27.

The mines of the eastern states yielded metals in 1928 valued as follows: Gold, $35,097; silver, $59,974; copper $4,256,517; and zinc $19,516,228. This was an increase in quantity and value for each. Gold output doubled.

AHE(16)

**Gold, Silver, Copper, Lead and Zinc in Montana in 1928.** C. N. GERRY. *Mineral Resources of the United States*, 1928, Part I, *United States Bureau of Mines*, May 27, 1930, pages 563–606.

The value of the mine production of gold, silver, copper, lead and zinc in Montana in 1928 was $55,365,249, an increase of 12% over 1927, largely because of the increase of 11% in copper production. Gold output increased nearly 9% and zinc 3%. Silver production decreased 3% and lead 6%. (Contains 9 footnote references.) AHE(16)

**Gold, Silver, Copper, Lead and Zinc in Utah in 1928.** C. N. GERRY. *Mineral Resources of the United States*, 1928, Part I, *United States Bureau of Mines*, May 19, 1930, pages 479–527.

The output of gold, silver, copper, lead and zinc from Utah mines in 1928 was valued at $79,258,904. The increase of $5,632,272 in value is chiefly due to the increase in the price of copper. Gold output increased nearly 10% and copper about 14%. These were the largest productions ever reported from Utah. Production of silver decreased more than 8%, lead more than 3% and zinc more than 5%. The state retained its position as leading silver producer, second in lead and copper, and fifth in gold and zinc. (Contains 16 footnote references.) AHE(16)

**Bauxite and Aluminum in 1928.** *Mineral Resources of the United States*, 1928, Part I, *United States Bureau of Mines*, April 12, 1930, pages 423–427.

In 1928 the bauxite output of the United States was 375,426 long tons, an increase of 17% in quantity. Imports decreased 2%. The value of new aluminum produced in the United States was $47,899,000, 22% increase. The value of secondary aluminum produced decreased 3%.

AHE(16)

**Sponge Iron Varies in Grade.** N. K. G. THOLAND. (Ekstrand & Tholand). *Iron Age*, Vol. 125, Mar. 20, 1930, page 850.

Being a discussion of Bradley Stoughton's paper abstracted in the March 1930 issue of *Iron Age*. See *Metals & Alloys*, June 1930, page 570.

VSP(16)

## PLANTS & LABORATORIES (17)

**Makes Rustless Steel Castings.** *Iron Age*, Vol. 125, April 3, 1930, pages 993–996.

Describes model plant built by the Ohio Steel Foundry Co., Springfield, Ohio, for the manufacture of heat-resisting alloy castings. The foundry has a capacity of 100 tons of castings per month. Castings are made from 8 oz. to 5 tons in size. Raw material comes in at one end and finished castings go out at opposite end of foundry. A 1 ton standard type of Swindell electric melting furnace is used. Usual furnace heat is 2500 lb. Two grades of heat resisting alloy castings are made, one containing 15% Cr and 35% Ni for resisting temperatures up to 2000° F. and the other containing 18% Cr and 8% Ni for resisting temperatures up to 1700° F. They are known as Fahrite No. 1 and 2, respectively. Another alloy having 25% Cr and under 2% Ni used for castings to resist high S atmosphere and sulphide ore and Zn and Pb oxides. This is known as C. S. Fahrite. Molds are dried in car type gas-fired oven. Products include furnace parts, conveyor links, tray, valves, enameling bricks, etc. VSP(17)

**Straight-Line Making of Sheets.** T. H. GERKEN. *Iron Age*, Vol. 125, April 10, 1930, pages 1064–1065.

Describes method of handling material in a new sheet mill of the Newton Steel Co., Monroe, Mich. Plant embodies some of the advantages of continuous sheet production, but retaining full flexibility of older type mill, which is adopted to rolling full-finished automobile body sheets. Laboratory tests are made from material (1) as taken from hot mill, (2) after normalizing, (3) after cold rolling and (4) prior to shipping. VSP(17)

**The New Role of Aluminum.** *Mechanical Engineering*, Vol. 52, May 1930, pages 533–535.

The article is devoted to a description of the new plant of the Aluminum Company of America at Massena, New York. GN(17)

## MACHINERY & SUPPLIES (18)

**Automotive Case Hardening Furnace.** *Automotive Industries*, Vol. 62, June 21, 1930, page 949.

The Hyro Furnace, placed on the market by the Hyro Manufacturing Co., New York City, is described providing an entirely automatic process of case hardening. GN(18)

## BIBLIOGRAPHIES (19)

**Bibliography of the Electrometallurgy of Iron. (Bibliographie der Elektrometallurgie des technischen Eisens.)** E. KOTHNY. Published by *Verein deutscher Giessereifachleute* (1930), 66 pages, price 6 R. M.

A classified list of references covering the electric furnace in the iron and steel industry appearing in the literature up to the end of 1928. An author index as well as a list of the periodicals included in the survey is included. About 2000 listings are given and while certain errors occur this bibliography will still prove of value. (19)

**A Bibliography on Effect of Temperature on Properties of Metals.** *A. S. M. E. Research Publication. American Society of Mechanical Engineers*, 1928, 27 pages, price 75 cents.

List gives 307 references in chronological order from 1828 including 1927 An author index is also included. (19)

## MISCELLANEOUS (20)

**Steel Plant Lubrication.** W. A. JAMES. *Preprint*, May 1930 Meeting, *American Iron & Steel Institute*, 15 pages; *Engineering*, Vol. 129, June 6, 1930, page 749.

General discussion from the point of view of lubricants rather than from that of the metallurgy of bearing metals. HWG & LM(20)

**Hydrogenation over Metallic Cesium.** DOUGLAS G. HILL & GEORGE B. KISTIAKOWSKY. *Journal American Chemical Society*, Vol. 52, March 1930, pages 892–894.

Ethylene and hydrogen in presence of distilled cesium at room temperature reacted with poisoning of the catalyst. Carbon monoxide and hydrogen also reacted, very rapidly at first but diminished rapidly also, giving evidence of poisoning. The activity of the cesium depended upon the surface condition. Results show that only adsorbed hydrogen is available for hydrogenation, and that hydride formation serves merely to diminish the free surface. MEH(20)

**Uses of Electron Bending. (Ueber Anwendungen der Electronenbeugung.)** E. RUPP (A. E. G.). *Metallwirtschaft*, Vol. 9, Jan. 10, 1930, pages 33–34.

Contains references. The bending action of electron rays is made use of for the examination of metal surfaces, the rays being bent by the space lattice. The presence of light hydrogen ions in the space lattice of heavy nickel has been proven. This would be impossible with X-ray examination. For the general examination of space lattices X-rays are better as electrons do not penetrate far enough. Electron rays are used to determine the position of atoms on the surface of a metal, up to 10 atom depth. Reactions of metals with gases, adsorption, light-electric effects and catalysis can be studied. So far hydrogen in nickel and iron has been investigated. Another possibility is the study of crystal growth, as in filaments for light bulbs. Structureless materials cannot be examined. Photographs can also be taken with electron rays. Three different types of apparatus are described. CEM(20)

**Breakage, Wear and Jointing of Rails.** *Engineering*, Vol. 129, May 30, 1930, pages 707–708.

From reports prepared by R. B. Abbott, S. Matsunawa, and Cambournac presented before the International Railway Congress, Madrid. LFM(20)

**The Present Status of Refinement of Alloys of Non-Ferrous Metals. (Ueber den Stand der Vergütung von Legierungen aus Nichteisenmetallen.)** *Zeitschrift Verein deutscher Ingenieure*, Vol. 74, Jan. 18, 1930, pages 82–84.

Report on papers read at the general meeting of the Institute of Metals and Deutsche Gesellschaft für Metallkunde. See *Metals & Alloys*, Mar. 1930, page 431. (20)

**The Platinum Industry of the Transvaal.** F. WARTENWELLER (Johannesburg Consolidated Investment Company, Ltd.) & A. KING (New Consolidated Gold Fields, Ltd.). *Engineer*, Vol. 149, May 16, 1930, pages 558–559.

From paper presented before the Empire Mining Congress, Johannesburg, entitled "The Metallurgy of Transvaal Platinum Ores." Deals with classification and description of platinum ores as well as the various processes of treatment. LM(20)

**The Recovery of Lead Storage Battery Scrap.** LESTER WILSON. (National Lead Co.). *Metal Industry*, N. Y., Vol. 28, April 1930, pages 162–163.

Gives metallurgical and economic aspects of industry. Describes method of recovery. A very large investment is required to build and operate a modern secondary lead smelter for profitable treatment of scrap storage batteries. VSP(20)

**Photo-Electro Metallurgy.** ROY W. DRIER. *Industrial & Engineering Chemistry*, Vol. 22, Feb. 1930, pages 153–157.

A new method of separating minerals, metals and metallurgical products on the basis of color and luster is described. The method utilizes a beam of light and a photo-electric cell actuated by the light reflected from the particles of material, and the separation is based on the differences in the reflective indices of the materials. Experiments on the separation of silver from copper, babbitt from brass, impurities from salt and azurite from malachite, and on fluorspar concentration by this method are described. These experiments indicate that the practicability of the method will depend upon the development of the mechanical phase of the separator. MEH(20)

**The Mechanical and Some Other Properties of the Hard Metal "Widia." (Ueber die mechanischen und einige andere Eigenschaften des Hartmetalls "Widia.")** C. AGTE. *Metallwirtschaft*, Vol. 9, May 9, 1930, pages 401–402.

Contains references. Widia is manufactured in the United States under the trade name of Carboloy. It is the hardest known material except the diamond. It is harder than ruby and can scratch sapphire. On Mohr's hardness scale it is 9.7. Its hardness and transverse strength compared with other metals are as follows:

| | Rockwell Hardness | Brinell Hardness | Transverse Strength |
|---|---|---|---|
| Hardened high speed steel | C 58 | 600 | 300 kg. per sq. mm. |
| Hardened "silver" steel | C 65 | 700 | 255 kg. per sq. mm. |
| Akrit (Stellite) | C 68 | 800 | 200 kg. per sq. mm. |
| Widia | C 75–85 | 2000 | 150–180 kg. per sq. mm. |
| Tungsten carbide melted and chilled | C 88–90 | > 2000 | < 35 kg. per sq. mm. |

The torsional strength of Widia is 100–140 kg. per sq. mm. and the linear coefficient of expansion is $5 \times 10^{-6}$ at 20–1000° C. Another advantage of Widia is that it does not oxidize. CEM(20)

**The Use of Wire Rope by Steam-Electric Generating Plants.** J. R. MCCAUSLAND. *Mechanical Engineering*, Vol. 52, May 1930, pages 529–532.

Proper care and lubrication appreciably increase the life of wire rope. A widely varying and inconsistent span of rope life when rope is used by the same individual in the same service, however, would indicate a lack of uniformity in materials or fabrication of the rope itself. GN(20)

**The Equilibrium between Bivalent and Quadrivalent Palladium and Chlorine in Hydrochloric Acid Solution.** HOMER B. WELLMAN. *Journal American Chemical Society*, Vol. 52, March 1930, pages 985–999.

From the equilibrium constant found, namely 4160 in normal HCl, the reduction potential for the reaction $PdCl_4^{--} + 2Cl^- = PdCl_6^{--} + 2E^-$ at 25° is computed to be −1.288 volts. MEH(20)

**The Cause of Ignition of Aluminum-dust during Manufacture. (Ueber die Ursachen der Entzündung des Aluminiumstaubes bei der Herstellung.)** F. RITTER. (Chemisch-Technische Reichsanstalt, Berlin.) *Zeitschrift Verein deutscher Ingenieure*, Vol. 74, Feb. 1, 1930, pages 145–148.

Read in the Committee on Explosives of the VDI. The production of aluminum dust is described; reasons for the ignition can be impact, sparks, friction. Explosives can develop great power. As aluminum dust oxidizes very easily means for reducing this have to be taken either by reducing the possibility of oxygen mixing with the dust particles or by permitting very fast oxidizing of the individual particles as long as air is there in excess. The grain-size of the dust is of extreme importance. A few examples of fires caused by oxidation are discussed. Ha(20)

**"Combination Metal" as a Material of Construction. (Verbundmetall als Konstructionsmaterial.)** HANS RUDOLPH. *Metallwirtschaft*, Vol. 9, Feb. 28, 1930, pages 189–191.

Combination metal has been used extensively under the trade name of "Doublé" for cheap jewelry and is now used for laboratory ware and other purposes. It consists of a base metal of copper, copper alloy or nickel covered with a thin sheet of silver, gold or platinum. The strength is obtained from the base metal and corrosion resistance from the precious metal. The two metals are welded together without the use of solder by packing in a box to exclude air, heating and pressing hydraulically. The temperature and pressure must be carefully regulated. It is impossible to separate the two metals after this process. It can be applied on one or both sides of the base metal. Tubes and wire can also be made. It can be rolled, pressed and drawn, but must be annealed between passes. Rolling forms an homogeneous, close grained metal, not brittle like an electroplated coating. The precious metal layer can be thin or relatively thick. For some irregularly shaped parts, and parts containing holes, electroplating is more suitable. Up until recently welding has been impossible as the two metals diffuse when heated. The Cu-Ag metal forms an eutectic of 72% Ag, 28% Cu which melts at 778° C. When trying to weld Ag to it, the Ag forms eutectic with more Cu. This is overcome by interposing a third layer of metal between the other two, either iron or nickel, which do not combine with either the base metal or precious metal. The edges are filed and cleaned. The Ag layer is welded with Ag wire. After cooling the Cu is soldered with silver solder and soldering fluid. The weld can then be hammered, annealed and polished. Cu-Au alloys are slightly harder to weld than Au and Fe alloy. CEM(20)

**Regularities in the Spectra of Lutecium.** WILLIAM F. MEGGERS & BOURDON F. SCRIBNER. *Bureau of Standards Journal of Research*, Vol. 5, July 1930, pages 73–81.

Up to the present time no significant regularities have been found in the spectra of any of the rare earth elements, 58 Ce to 71 Lu. A study of the arc and spark spectra of the last of these, lutecium, resulted in a separation of the lines into three distinct classes: (1) Those characterizing neutral atoms, constituting the Lu I spectrum; (2) those due to singly ionized atoms, the Lu II spectrum; and (3) a small number of lines ascribable to doubly ionized atoms, the Lu III spectrum. Regularities have been discovered in each of these spectra. The normal state of neutral Lu atoms is represented by a $^2D$ spectral term arising from the electron configuration $s^2d$; its levels are separated by 1993.9 wave numbers. The normal state of $Lu^+$ atoms is described by a $^1S$ (ss), and metastable terms $^1D$, $^3D$ (ds), $^3F$ (dd) have also been established. A $^2S$ (s) term describes the normal state of $Lu^{++}$ atoms. There is no evidence of *f* electrons playing any part in the production of the spectra; it is concluded that the 14 *f* electrons in Lu form a closed shell of considerable stability. The structures of Lu spectra resemble those of Y more closely than those of La or Sc. (20)

**Beryllium Deposits in the Alps. (Alpine Berylliumlagerstätten.)** A TORNQUIST. *Metall und Erz*, Vol. 27, April 1930, pages 177–179.

Beryllium is an important metal and alloying element on account of its low specific gravity, 1.8, which is 33% lighter than Al. Its present cost of $125 to $150 per lb. makes its use impossible. To be economical its cost would have to be reduced to at least $12 per lb. The high cost is due to the high cost of the raw material, the high cost of producing from it salts suitable for electrolysis such as sodium beryllium fluoride, and the high cost of the electrolytic refining process. At present the only source of Be is in South Dakota, where it is carried for 3 days on mule back to the nearest railroad. These deposits contain at best 55–56% beryl which is equivalent to 2.7% Be. An extensive survey of the East Alps was undertaken by the author to discover new sources of Be. The presence of beryl, $3BeO.Al_2O_3.6SiO_2$ is not an indication of other workable ores. It is best obtained from minerals which are infiltrated with Be, even though with a low percentage. A large number of samples of minerals were analyzed. Be was found in certain pegmatities, which consist of feldspar with dark blue to blue gray quartz streaks. Also in minerals containing muscovite and streaks of black turmaline and blue beryl. Some of these deposits contained as high as 3% BeO. Due to the easy accessibility of these deposits their working on an economical basis is considered possible. CEM(20)

**A Study of the Reaction between Hydrogen Sulphide and Silver.** S. LILIENFELD & C. E. WHITE. *Journal American Chemical Society*, Vol. 52, March 1930, pages 885–892.

It has been found that hydrogen is not formed as the result of the reaction between hydrogen sulphide and silver in the presence of air and moisture, and that oxygen and moisture are necessary for reaction to take place at ordinary temperatures and pressures. MEH(20)

**Resonance and Quenching of the Third Principal Series Line of Caesium.** C. BOECKNER. *Bureau of Standards Journal of Research*, Vol. 5, July 1930, pages 13–18.

A helium discharge is used as a source for the study of the resonance radiation from the third principal series line of caesium. This is possible, due to the coincidence of a strong helium line with the caesium line. A number of caesium arc lines are also observed in the fluorescent radiation; they have their origin in lower levels populated by radiation transitions from the initial level ($4P^1/_2$). The effect of helium on the fluorescent radiation is studied. It is found that collisions between helium and caesium atoms in the $4P^1/_2$ state transfer the latter only to states differing by less than several hundredths of a volt from the initial state. Transfers to states differing by as much as 0.18 volt are improbable. (20)

**Photo-Ionization of Caesium by Line Absorption.** F. L. MOHLER & C. BOECKNER. *Bureau of Standards Journal of Research*, Vol. 5, July 1930, pages 51–71.

The ionization of caesium by line absorption has been investigated by means of the space-charge method. Light resolved by a monochromator is used and the relative sensitivity in the region of line absorption, as compared to the region of continuous absorption beyond the limit, is measured. Ionization by a continuous spectrum.—The effect is directly proportional to the light intensity. Relative sensitivity is independent of electrical conditions and temperature of the vapor. The reduction of the effect by an absorbing column of caesium vapor in the light path indicates that the effective absorption line width is about 0.007 A. U. at 0.003 mm. pressure. This width increases with pressure. Relative sensitivity rises rapidly with vapor pressure between 0.0002 and 0.004 mm. and drops slowly above 0.01 mm. Ionization by monochromatic light.—A helium line at 3888 A. U. is coincident with one of the caesium lines and measurements of the absorption of this line by caesium and of the photo-ionization produced give the probability of ionization of an excited atom in the $4\ P_1$ state as a function of the vapor pressure. Discussion.—Measurements of relative sensitivity to continuous spectrum excitation are corrected for absorption and slit width to give the probability of ionization of excited atoms in states 4–8 P and higher states near 9 P, 12 P, 16 P and 25 P. This probability is shown to be proportional to the chance that an excited atom collides with another caesium atom during the life of the excited state. The probability of ionization at a collision varies from nearly one for higher states to 0.003 for the 4 P state. Results are consistent with a theory of Franck's that ionization results from the combination of excited and normal atoms to form molecule ions. (20)

# Book Reviews

**Automobile Steels.** ALBERT MÜLLER-HAUFF & KARL STEIN. Translated by Hans Goldschmidt. John Wiley & Sons, Inc., New York, 1930. Cloth, 6 × 9½ inches, 219 pages, 77 figs., 77 tables. Price, $3.50.

This book was planned to bring together in usable form widely scattered information in the hope that it would become a practical manual for the designer, the automobile plant manager, the steel plant manager, the business man and the mechanic, but it is doubtful whether the widely varying interests of these groups have each been given adequate consideration within the allotted two hundred pages.

However, these different groups who supervise the manufacture or application of automobile steels, or who work with them, will find the assembled data of interest especially as regards foreign practice and its comparison with American practice.

The subject matter is handled from several angles, such as steel composition (carbon and alloy steels), processing (case hardening steels, "heat treating" steels) and special purpose steels (ball bearing, magnet, spring, stainless and valve steels). Also the original German text has been amplified by additions of chapters on American standards for testing materials and the standardization of steels, a series of pictures of fractures and a group of tables giving the steel specifications of prominent American and foreign automobile manufacturers.

On the whole the treatment is rather sketchy and in the mind of the reviewer the authors' attempts at simplification and condensation have been carried somewhat too far, even for the lay reader. Probably the best example of this is found in Chapter II where the influence of the important alloying elements which form the basis of so-called automobile steels is disposed of in three short paragraphs. Likewise, Chapter V, which is intended to cover the principles underlying the selection of steels for different automobile parts, comprises five pages and consists largely of a record of steels employed.

The terminology is not always precise, due in all probability to the tendency for literal translation. This is especially marked in Chapter II relating to steel manufacture but is noticeable elsewhere.

Those who are intimately acquainted with the problems of steel applications in the automotive industry will probably not consider the book of much benefit either to expert or layman, but despite detailed shortcomings along the lines outlined it contains a condensation of much data and on this account should find favor in the hands of some of those groups for which the book was prepared.—H. J. FRENCH.

Die **Geschichte des Wismuts Zwischen 1400 und 1800.** BY E. O. VON LIPPMANN. Julius Springer, Berlin, 1930. Paper 6½ × 9½ inches, 38 pages. Price, 2.80 RM.

This comprehensive review of the early history of bismuth covers the literature on the subject from the first recorded mention of the metal and its compounds (about 1200 A. D.), through the first records of bismuth mining in the Schneeberg district in 1477, and up to the final recognition of bismuth as a separate individual metal, due to the work of Pott in 1739 and of Geoffroy in 1753. Throughout this period bismuth was generally confused with lead, tin, zinc and antimony. The references to the use of bismuth or its compounds, therefore, are more of historical than of practical interest. For instance a pigment prized for its blue color apparently was a cobalt pigment rather than a bismuth pigment, and the "bismuth" cosmetics may have been white lead.

Professor von Lippmann believes that the increasing demand for bismuth from about 1450 on, was associated with the development of the printing industry. References are given to the use of bismuth-antimony, bismuth-tin-lead and bismuth-lead-antimony as early type metals. Fusible alloys (which contained bismuth) were known and probably were used for taking impressions from wood cuts.

The chapter dealing with the origin of the name lists 21 variations in the spelling. The name apparently is of German origin, but the derivation is uncertain. Several suggestions are recorded dealing with "Wiesen" (meadows), "muten" (to operate a mine), "weisse masse" or "weisse materie" (white material), and "glismat" (glistening mass). In a fanciful suggestion the tarnish colors which develop on bismuth are likened in appearance to colored flowers in a meadow.

Historical reviews such as this one of bismuth are always of interest, particularly in the quotations from ancient and obscure manuscripts. Professor von Lippmann was fortunate to have access to these rare early manuscripts, and deserves considerable credit for his interest and patience in assembling this material.—J. G. THOMPSON.

**Airplane Welding.** BY J. B. JOHNSON. Goodheart-Willcox Co., Inc., Chicago, 1929. Cloth, 6 × 9 inches, 295 pages, 152 figs. Price, $3.50.

Rapid expansion in the airplane industry makes it essential that every mechanic, draftsman and engineer engaged in the construction or repair of airplanes has a thorough knowledge of the principles of welding as applied in this particular field. In this book, the author has attempted to give a description in non-technical language of the designs, materials and practices which have proved to be most satisfactory for this type of construction.

Various methods of joining metals are briefly described, but the greatest attention is given to welding as that method of fabrication has practically superseded other forms. The equipment and various methods of welding, the metallurgical processes involved in the making and testing of welds and the design and construction of welding jigs are covered in considerable detail.—D. L. MATHIAS.

**American Standards Year Book—1930.** American Standards Association, New York. Paper, 7¾ × 10½, 104 pages.

Since the last issue of the yearbook 16 new standards have been approved by the Association. Up to the present, the Association has approved 166 standards, and projects for 171 other standards are under way. These are listed. The balance of the information contained is practically a repetition of the last issue, which was reviewed in *Metals & Alloys*, Nov. 1929, page 251.—R. R.

**Melting Iron in the Cupola.** BY J. E. HURST. Penton Publishing Co., Cleveland, Ohio, 1929. Cloth, 6 × 9½ inches, 220 pages, 126 figs. Price, $6.00.

This book of 220 pages is the outcome of a series of articles on the subject, written for the *Foundry*, and gathered into a volume by the editorial staff. As might be imagined, the viewpoint of the author is distinctly a British one, and many of his statements will not be accepted as correct here in America, as the operating methods are different, the materials used require more exact treatment, the possibility of oxidizing the iron in melting—with resulting defective castings—is well known by American foundrymen, but is not touched upon in the treatise in question. It is but natural, however, that the experiences and methods of one country cannot be made to fit those of another.

The volume contains a large mass of cupola data and covers the subject from the earliest times up to the very latest in cupola experimentation. It is the work of a student of the subject and deserves great credit. For the record of investigations made, alone, the book should be in every foundry laboratory and office. With all the chapters on cupola construction, operation, combustion, materials, etc., there seems to be lacking the authors' definite judgment of the good and bad to be found in what the foundryman is asked to buy, and in what he is told to do. Many of the devices shown have been proven failures in practice, and much of the investigation is "professorial." But few conclusions are drawn from the mass of material presented (as for instance in charging machines), which will disappoint the foundryman looking for enlightenment in his operating troubles. The inference would be that the author is more at home in the laboratory than in the foundry itself.

As a book on melting iron in the cupola, it serves as a worthy successor to Dr. Kirk's classic and entirely out-of-date treatise on the subject.—RICHARD MOLDENKE.

**Standard Yearbook—1930.** Bureau of Standards Miscellaneous Publication No. 106. Compiled by National Bureau of Standards. United States Printing Office, Washington, D. C., 1930. Cloth, 6 × 9¼ inches, 301 pages. Price, 75 cents.

This publication is the Year Book of the American Standards Association. It is informational, discussing the aims and objectives of this association, which is a federation of 43 national technical societies, trade associations and government bodies. It contains a list of publications, a statement concerning the membership and their cooperation, outlines typical projects, explains how American standards are developed and gives in some detail a list of projects and their present status.

The projects of special interest to the readers of *Metals & Alloys* with the reports covering them are listed here: Embrittlement of Sheet Duralumin—National Advisory Committee for Aeronautics, Technical Notes Nos. 282–285, 304, 305; Fatigue of Alclad Duralumin; Welded Joints in Tubular Members for Aircraft; Aircraft Tubing—National Advisory Committee for Aeronautics, Technical Note No. 307; Corrosion—Test Methods, *Bureau of Standards, Journal of Research*, Vol. 1 (1928), page 255, Vol. 3 (1929), page 375, Vol. 2 (1929), page 431, Soil Corrosion, *Bureau of Standards, Journal of Research*, Vol. 3 (1929), page 275; Cooling and Lubrication of Cutting Tools; Gases in Metals; Properties of Pure Metals, *Bureau of Standards, Journal of Research*, Vol. 3 (1929), page 1029; Wrought Iron, *Bureau of Standards, Journal of Research*, Vol. 3 (1929), page 953.

This is followed by details concerning cooperative bodies, the constitution and by-laws of the association, details as to available publications and officers' reports.—R. R.

**Dental Metallurgy.** BY A. JOHNSTONE BROWN. E. & S. Livingstone, Edinburgh. 1928. Volume XI, Outlines of Dental Science. Cloth, 5 × 7¼ inches, 190 pages. Price, 7 s. 6 d.

The preface states: "merely an outline of Dental Metallurgy, describing the source, reduction, properties and uses of the metals commonly used." A brief introduction is followed by Chapter I, Physical Properties of Metals, Chapter II, Alloys, Pyrometers, Chapter III, Dies, Fusable Metals and Chapter IV, Solders, Fluxes, Furnaces, Ores. In Chapters V–XX the 18 common metals are discussed. The general plan used in discussing these metals is as follows: source, process metallurgy, properties, dental uses, alloys, etc. Frequently there is included assay and qualitative testing methods. Chapter XI departs from the general scheme and is a special discussion of amalgams.

A large amount of the material given is of no special interest to the dentist. There are no references given in the text. The complete neglect of American researches in the field of dental metallurgy is very conspicuous. The whole text is lacking in new and modern information. Surely it does not represent modern American practice and knowledge of the profession.

Finally, there are some rather serious errors. On page 28 gold and silver are represented as forming alloys which are mechanical mixtures instead of a complete series of solid solutions. On page 32 "pyrometers for dental use should register up to 4000° C." On page 47 "Fireclay muffles are always used in electric furnaces....." Page 69, "When the proportion of platinum (in gold) exceeds 5 percent the alloys are brittle....." Page 94, "Palladium and gold form alloys which are greyish white in colour, hard and brittle" surely is not in agreement with the finding of reliable investigations. Page 101 gives the fineness of sterling silver as 995. Page 156 gives the fusion temperature for wrought iron as 1000° C. Page 157, "Steels containing from 1–5 percent of carbon are called mild steels....." Also "mild steels generally contain from 4–1 percent of manganese....." Considerable space is given to a discussion of cementation as a steel making process, while no mention is made of the electric furnace process.

This publication will be of little use to the practicing dentist or student in America.—O. E. HARDER.

**Platers' Guidebook.** OLIVER J. SIZELOVE. Metal Industry Publishing Company, New York, 1930. Paper, 5 × 8 inches, 54 pages.

A pocket manual containing concise information on electroplating, formulae for solutions and coloring metals, and methods of volumetric analysis for different plating solutions. It also contains 46 pages of advertising on electroplating supplies.—R. R.

**Metallkeramik.** Dr. Franz Skaupy. Verlag Chemie, Berlin, 1930. Paper 6 × 9½ inches, 60 pages, 15 figs. Price, 6 R. M.

An interestingly written paper with 18 illustrations describing the production of metallic objects using powdered metal. The author uses the term ceramics of metals to describe the process because of its similarity to the production of clay ware. He discusses the importance of crystal form and size on the strength and pliability of metallic objects and its relation to the production of metallic objects using powdered metal and fritting or sintering them to a solid mass as is done in the manufacture of the recently developed but well-known material Widia. Metals may be produced by, for example, reducing the oxide in powder form, by means of hydrogen or carbon-monoxide. Carbon as a reducing agent may be replaced by such strongly basic metals as the alkaline earths and the alkalis. Having obtained the metal, in a more or less friable form, it may then be reduced by one of a number of methods depending on its characteristics, i. e., crushing, grinding, sublimation or spraying. The particle size distribution is next in importance to the chemical composition. In this work particles from 0.1–100 $\mu$ are considered. Particle size distribution may be estimated directly by means of the microscope or indirectly by dye absorption, sedimentation, elutriation or similar methods. The particle size of the product in reduction processes may be varied by the speed of the gas stream, the thickness of the bed of metal or the moisture content of the reducing gas. It is of more importance, however, to be able to classify powder containing a range of particle sizes into fractions each of which will contain particles approximately one size. Air or water elutriations are recommended for this purpose. The powder may be pressed into friable shapes of simple geometrical design using hydraulic presses and pressures of from 1–10 thousand atmospheres. The shapes are then sintered at a comparatively low temperature in order to impart sufficient strength to permit further forming by grinding, filing, turning etc. The formed pieces are then fused or "vitrified" at a temperature predetermined by the nature of the metal. This must be done in a neutral or reducing atmosphere. An oven may be utilized or the object itself may form the resistor in an electrical circuit. It was also found advantageous to press at elevated temperatures. Forming of pastes with an organic bond, or a metallic colloid is common, i. e., the production of tungsten filaments and also rods for electrical resistors. Alloys may be formed by intimate mixture of two or more metallic powders and with or without a bonding material which is driven off during the heating. There are two distinct classes: in one none of the powders actually melt and in the other one or more may melt. Alloys may also be formed by permiting a porous object of one metal to absorb another metal (heated to fluidity) into its pores. Tungsten carbide will absorb molten copper with avidity. Objects are characterized by their porosity which is relatively higher than for objects formed by casting. Crystal size is an important factor and may be determined by etching a polished surface and examining microscopically. The electrical resistivity is higher than for cast metals and may be varied by varying the porosity. However, the resistivity does not remain as constant at high temperatures as it will, for example, in a carbon filament. The ceramically formed metals may be worked in the cold as well as the regular material and inclusion of impurities may have equally deleterious effects. The author describes in detail the methods used in the production of various objects from tungsten, and describes the production of filaments, plates, and rods of tungsten and cutting tools of tungsten carbide. The method is of especial value in the forming of such high melting point metals as tungsten, molybdenum, tantalum, etc.—R. F. Geller.

**Hütte. Taschenbuch für Eisenhüttenleute.** Wilhelm Ernst und Sohn, Berlin, 4th edition, 1930. Cloth, 968 pages, 582 figs. Price, 35 RM.

The new fourth revised edition of the "Hütte" might reasonably be called a gold mine for the ferrous metallurgist. The digging may not always be easy in such a comprehensive handbook, written by many of the best German experts in the fields dealt with, but the more time the digger spends in reading the book the more he will be rewarded.

The book is up to date and compared with the 3rd edition, has a number of new chapters. Many other chapters, to be found in the former editions, were rewritten. This is true, for instance, of the chapters: Physical and Chemical Properties of Iron, Physical Testing, Heat and Power Economy and Fuels and Furnaces. Among the chapters appearing for the first time we find those on: Heat Treatment of Steel, Steel Standards, Slags, Resistance Against Corrosion and Acids, Non Ferrous Metals, High Speed Cutting Metals, Alloying Elements of Steel, Welding Practice, Conversion Tables for Measures of Different Countries.

The arrangement of the material dealt with has found a satisfactory solution; a point of essential importance for a handbook covering a vast field. Taking into account the fact that the book was written by group of men we cannot expect an absolute "balance" between all the contributions. Some are written from a different viewpoint than others; some are more in detail than others. The chapter on wire drawing, for instance, is an exceptionally well written treatise, whereas the production of cold rolled sheets and strips s only briefly covered.

A handbook is never complete and will never be complete, thus the possibility of improvement is always present and the German metallurgists will certainly do their best to keep for their "Hütte" its reputation as the best German handbook of ferrous metallurgy. A. book which has gone through three editions in the last ten years is recommended by this fact alone. A handbook of a similar conception as the "Hütte" is certainly needed by American metallurgists.—G. Neuendorff.

**Eisenguss in Dauerformen.** By Friedrich Janssen. Julius Springer, Berlin, 1930. Paper, 6½ × 9¾ inches, 92 pages, 63 figs. Price, 10.50 RM.

This excellent book of 92 pages covers the history and present-day status of the art of making castings in the so-called "permanent mold." The German designation "Dauerform," literally translated into "Endurance mold," is unquestionably the correct definition. Our own title has it the "long-life" mold.

The author divides the subject into three parts. Molds of more or less permanency for large and small castings to be made in quantity; molds for centrifugal processes, and molds for die-castings. The several processes coming under each head are described in detail, as also their application and requirements—metallurgical and mechanical. The properties of the castings made, as in contradistinction to those made in sand-molds, are discussed, and the reasons given for the failure or partial failure of each development.

The conclusions derived are that with the exception of isolated cases, for castings specially adapted to a production of this kind, as in centrifugal pipe, the subject of long-life molds is still a long way off in its satisfactory solution. The sand-mold has been so perfected, and is still in process of betterment, that as a general proposition the mold for repeated use cannot well compete. Nevertheless, the author advises continued experimentation, for the destruction of a mold each time a casting is made does seem like an economic waste of labor and material.—Dr. Richard Moldenke.

# Reviews of Manufacturers' Literature

*In this department we shall list each month a selection of the catalogs, books, treatises and other printed matter issued by manufacturers which, in our judgment should be of interest to the readers of* Metals & Alloys. *Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter for consideration by the editor of this department are invited to do so, and it is suggested that* Metals & Alloys *be placed on the regular mailing list so that advance copies of any material of interest to the metallurgical field may automatically come to this department*—Editor.

**Foundry Equipment.**—A new book illustrating and describing recent installations of Link-Belt Foundry Equipment for the preparation and handling of sand, molds and castings. This book, No. 1090, illustrates and describes the most recent practice in modern foundries, and pictures actual installations in many types of foundries throughout the country. Other recently issued books of interest to Foundrymen are: No. 1120, Link-Belt Vibrating Screen—the ideal sand reclaiming and shake-out unit; No. 1118, describing the Saginaw Malleable Foundry; and No. 1119, covering the American Manganese Steel Company foundries. Link-Belt Company, 910 S. Michigan Ave., Chicago, Ill.

**Dilatometers.**—Catalog D-1, a 14-page illustrated pamphlet describing the Chevenard equipment for thermal studies of steel, alloys, refractories, glass, etc. The laboratory at the Steel Works at Imphy, France, has long been a center of studies of a purely scientific nature while serving also as a guide and check-up on the mills. Invar, elinvar, fixinvar and other special alloys are the result of the researches of Dr. Charles Eduard Guillaume, Director of the International Bureau of Weights and Measures, which have been carried on in connection with this laboratory. For thirty years this laboratory has been building up an enviable reputation. The present catalog deals with apparatus devised by Pierre Chevenard of this laboratory, a mining engineer and professor at the École Nationale Supereiure des Mines at St. Etienne, who has made a well-known series of researches at this laboratory. The R. Y. Ferner Co., Investment Bldg., Washington, D. C.

**Automatic Arc Welding Data.**—Data Bulletin No. 14 features automatic arc welding, a number of automatic arc welding applications are described as well as actual cost comparison of hand and automatic welding. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

**Copper Brazing Furnaces.**—20-page bulletin points out the disadvantages of spelter brazing, at the same time emphasizing the advantages of copper brazing. The method used in copper brazing is described, metals suitable and unsuitable for brazing are given. A number of applications are illustrated and the furnaces required for copper brazing are illustrated and described. Bulletin GEA-1291. General Electric Company, Schenectady, N. Y.

**Arc Welding of Structural Steel.**—Publication S. P. 1879 covers the progress in structural steel welding. The subjects treated cover the strength of welded joints, design data, building code, estimating costs and bridge specifications. Numerous illustrations, a review of the progress made in structural arc welding, and a discussion of future and possible developments in arc welding are included. 32 pages. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

**Arc Welding Structural Steel.**—24-page bulletin covers the development of structural joints and some of the advantages of arc welding. Tables and diagrams showing unit stress of specimens, standard single-angle connections, standard single-channel tension connections, standard single-tee connections are included. Typical arc-welded truss details are shown by line drawings. Bulletin GEA-1161. General Electric Company, Schenectady, N. Y.

**Chemicals—Price List.**—Catalogue of C. P. Chemicals & Acids and other laboratory & technical chemicals dated July 1, 1930 has been issued by the J. T. Baker Chemical Co., Phillipsburg, N. J.

**New Optical Pyrometer.**—Leaflet describes an instrument for color temperature measurement, the color temperature being determined by the intensity ratio of two colors in the spectrum of the radiating body, which ratio is ascertained by the light filter of the pyrometer, called the "Pyrovisor." American Demag Corporation, 310 South Michigan Ave., Chicago, Ill.

**Calcium Molybdate.**—48-page booklet, 4-½ × 6¾ inches, bound. This booklet points out the advantages and limitations of calcium molybdate and indicates the manner in which it is best employed in the different metallurgical processes. Climax Molybdenum Co., 295 Madison Ave., New York, N. Y.

**Recording Controllers for Correct Carburizing.**—Direct mail piece illustrates the L & N recording controllers for maintaining constant temperatures in carburizing controllers. Leeds & Northrup Company, 4901 Stenton Ave., Philadelphia, Pa.

**Cutting Compound.**—Direct mail piece illustrates the results obtained using "Hocut" transparent, water soluble cutting coolant for machining. E. F. Houghton & Co., Philadelphia, Pa.

**Electrically Heated Platens.**—Leaflet TB-24 is a reprint of an article from *Engineers and Engineering*, by Harold E. Trent, entitled "Electrically Heated Platens." Harold E. Trent Company, 439 North 12 Street, Philadelphia, Pa.

**Stainless Steel Castings.**—Direct mail piece illustrates some stainless steel castings supplied for the American Cup Defender "Enterprise" by the Lebanon Steel Foundry, Lebanon, Pa.

**Strip and Wire Heating Furnace.**—Bulletin 190 describes the construction of Falcon continuous electric furnaces for heat treating strip metal and wire. H. O. Swoboda, Inc., 3400 Forbes St., Pittsburgh, Pa.

**Gas Producer Operation.**—Booklet entitled "Improved Gas Producer Operation" has been issued by L. J. Wing Mfg. Co., 154 West 14 Street, New York, N. Y.

**Nibbling Machine.**—New Catalog describes in detail how the machine operates, showing how sheet metal can be cut in a fraction of the time required by other methods. Andrew C. Campbell, Inc., Waterbury, Conn.

**Gas-Fired Furnaces.**—Direct mail piece illustrates testimonial letter on 4 SC rated gas-fired oven furnaces. Surface Combustion Company, 2375 Dorr Street, Toledo, O.

**Better Methods.**—The May issue of the publication published monthly by Beardsley & Piper Company, 2541 North Keeler Ave., Chicago, Ill., contains the following articles: "Standard Foundry Company and Better Methods" and "The Flow of Metals in Molds." The latter is reprinted from *Metals & Alloys*.

**AMSCO Bulletin.**—The June issue of the periodical contains a number of illustrations of manganese steel castings. An article compares Amsco Manganese Steel with Alloy Steels. American Manganese Steel Company, Chicago Heights, Ill.

# Patent Department

*Through an arrangement with Mr. W. M. Corse, Metallurgical Engineer, Washington, D. C., who operates a well-known Patent Information Service, we are able to publish every month a list of important patents in the metallurgical field from the United States, Canada and Europe. The following countries will be included in the European listing: England, Germany, France, Switzerland, Denmark, Norway, Sweden and Italy.*

*If our readers wish more information about any of the patents listed below they can get it by writing to our Patent Department, and mentioning the fact that they have the reference in* METALS & ALLOYS. *We will be prepared to mail copies of United States Patents to clients within twenty-four hours of date of issue by special arrangement. Photostatic copies, translations of claims and of full text of foreign patents will be supplied if desired.*

*This service is furnished under special arrangement with Mr. Corse's organization at most reasonable rates. Full information can be secured by writing to Patent Department,* METALS & ALLOYS, *419 Fourth Avenue, New York.*

## United States Patents

*Subject of Invention*, Patentee, Patent No. and Filing Date.

*Method of making magnetic alloys.* V. B. Browne. Reissue patent No. 17,771. (Original patent No. 1,570,229, filed Mar. 19, 1925.) Mar. 17, 1930.

*Molding apparatus for sash weights.* H. Loudenslager and W. J. Loudenslager. No. 1,772,463. May 15, 1928.

*Method of making valves.* H. Ford, assignor to Ford Motor Co. No. 1,772,482. July 20, 1928.

*Casting magnesium and alloys therefor.* H. Kelley, assignor to The Dow Chemical Co. No. 1,772,490. Jan. 13, 1926.

*Method and apparatus for die rolling.* W. H. Donner. No. 1,772,538. June 4, 1927.

*Tin-pack-handling mechanism for heating furnaces.* J. W. Perry. No. 1,772,554. Sept. 8, 1928.

*Inductor-type furnace.* E. F. Northrup, assignor to Ajax Electrothermic Corp. No. 1,772,579. Dec. 7, 1928.

*Press for forging or shaping metal.* J. E. Dobson, assignor to The Cleveland Punch & Shear Works Co. No. 1,772,599. Dec. 27, 1926.

*Sizing, coining or squeezing attachment for power presses.* N. W. Dorman, assignor to The Toledo Machine & Tool Co. No. 1,772,600. May 12, 1928.

*Tuyère for metallurgical blast furnaces.* W. A. Haven. No. 1,772,864. Mar. 29, 1926.

*Device for pressing articles.* P. C. Christiansen. No. 1,772,707. Feb. 25, 1929; in Denmark Mar. 1, 1928.

*Sheet-metal loading for freight cars.* R. T. Romine. No. 1,772,731. June 23, 1926.

*Portable platform.* R. T. Romine. No. 1,772,732. Sept. 3, 1926.

*Industrial truck.* R. T. Romine. No. 1,772,733. Oct. 28, 1926.

*Method and apparatus for handling metal.* R. T. Romine. No. 1,772,734. (Original filed Aug. 10, 1926.) Apr. 7, 1927.

*Method for handling material.* R. T. Romine. No. 1,772,735. May 5, 1927.

*Portable platform.* R. T. Romine. No. 1,772,736. June 16, 1927.

*Coated metal article and process of applying coatings thereof.* L. E. Barringer, assignor to General Electric Co. No. 1,772,743. Jan. 5, 1927.

*Magnetic alloy.* B. Fetkenheuer and H. Neumann, assignors to Siemens & Halske Akt.-Ges. No. 1,772,771. May 7, 1928; in Germany May 20, 1927.

*Device for operating mold members.* A. T. Bateman and A. Irvine, assignors to Bohn Aluminum & Brass Corp. No. 1,772,795. Sept. 4, 1928.

*Bearing for rolls in rolling mills.* L. Rixecker, assignor to Röchling'sche Eisen-und Stahlwerke Akt.-Ges.- No. 1,772,817.–Aug. 23, 1928; in Germany Sept. 6, 1927.

*Method of and means for electro-plating.* W. S. Murray, assignor to Oneida Community, Ltd. No. 1,772,840. Mar. 8, 1924.

*Treatment of iron and steel.* M. Hirsch. No. 1,772,866. July 2, 1927.

*Charging apparatus for cupolas.* M. F. Beetham, assignor to Whiting Corp. No. 1,772,884. Oct. 23, 1926.

*Cushion for sheet-metal presses.* F. J. Rode, assignor to Marquette Tool & Mfg. Co. No. 1,772,914. Aug. 20, 1928.

*Process for producing aluminum compounds.* T. R. Haglund, assignor to International Patent Corp. No. 1,772,936. Apr. 6, 1925; in Sweden Apr. 17, 1924.

*Process for producing aluminum and aluminum alloys.* T. R. Haglund, assignor to International Patent Corp. No. 1,772,937. Oct. 19, 1925; in Sweden Nov. 15, 1924.

*Manufacture of soldering pastes.* G. Knoth. No. 1,772,952. Mar. 29, 1929; in Germany Apr. 3, 1928.

*Process for recovering molybdenum from petroleum hydrocarbons.* A. Oberle. No. 1,772,960. May 20, 1929.

*Mandrel for use in rolling machines.* E. Keller. No. 1,773,004. Dec. 17, 1929; in Germany Nov. 20, 1928.

*Process for the pickling of metals.* E. Chapman and A. Hill, assignors to Imperial Chemical Industries, Ltd. No. 1,773,024. Apr. 12, 1929; in Great Britain Apr. 14, 1928.

*Mold or plate hanger.* W. S. Jones. No. 1,773,042. June 13, 1929.

*Electric welding.* J. J. Vienneau, assignor to General Electric Co. No. 1,773,068. Aug. 8, 1927.

*Method of spot electroplating.* J. A. Flanzer, assignor to Technidyne Corp. No. 1,773,135. Oct. 1, 1927.

*Process for the manufacture of silicon steel.* W. J. Wooldridge. No. 1,773,157. May 26, 1928.

*Process for cupric-oxide removal.* (From copper.) W. T. Anderson, Jr. and L. F. Bird, assignors to Hanovia Chemical and Manufacturing Co. No. 1,773,160. Oct. 28, 1927.

*Electroplating tank apparatus.* A. H. Hannon. No. 1,773,179. June 22, 1928.

*Two-stage method of chlorinating ores.* T. A. Mitchell, assignor to Lafayette M. Hughes. No. 1,773,235. Apr. 6, 1927.

*Inhibitor.* I. Williams, assignor to The Grasselli Chemical Co. No. 1,773,247. Aug. 9, 1928.

*Method of making furnace roofs.* G. E. Hilliard. No. 1,773,359. Apr. 10, 1928.

*Liquid-fuel torch.* T. C. Wilson and R. J. Petty, assignors to Liquid Fuel Cutting & Welding Torch Corp. No. 1,773,418. Apr. 5, 1929.

*Apparatus and method of casting self-hardening materials.* R. Lindsey. No. 1,773,429. Dec. 3, 1928.

*Apparatus for bending angle irons.* T. A. McDonnell. No. 1,773,430. Dec. 22, 1927.

*Press for drawing sheet metal and the like.* F. J. Rode. No. 1,773,438. Apr. 8, 1929.

*Cushioning device for drawing presses.* F. J. Rode. No. 1,773,439. Apr. 13, 1929.

*Catcher for rolling mills.* O. J. Le Boeuf. No. 1,773,463. Oct. 27, 1928.

*Press for extruding seamless tubes from unbored billets of metals and alloys.* A. Liebergeld and F. Singer; said Liebergeld assignor to F. Singer. No. 1,773,464. Aug. 2, 1929. (Original application filed Jan. 9, 1926); in Germany Jan. 12, 1925.

*Attachment for welding machines.* E. W. Little. No. 1,773,465. May 27, 1929.

*Method of producing the blast required for blast-furnace or similar plants by means of calcium carbide.* G. Malyoth. No. 1,773,491. June 23, 1928; in Germany Oct. 4, 1926.

*Process and apparatus for treating galvanized articles.* H. B. Newhall, H. W. Pleister and C. A. Giblin. No. 1,773,495. Aug. 21, 1928.

*Metal carrier.* J. R. Coe, assignor to The American Brass Co. No. 1,773,518. Dec. 23, 1929.

*Metal-working press.* F. J. Rode. No. 1,773,548. Aug. 16, 1929.

*Method of forming ringlike members.* W. J. Boyle, Jr., assignor to The Boyle Manufacturing Co., Inc. No. 1,773,566. Sept. 8, 1927.

*Arc-welding electrode.* B. Turner, assignor to The Ferro-Arc Welding Co., Ltd. No. 1,773,653. June 19, 1928; in Great Britain, Aug. 26, 1927.

*Lead column, pipe or the like.* E. Voituron, assignor to Société Belge De L'Azote. No. 1,773,655. May 17, 1928; in Belgium May 20, 1927.

*Sand-slinging machine.* E. P. Jansson, assignor to AB. Axel Christiernsson, and AB. Eksjö Mekaniska Verkstad. No. 1,773,694. May 12, 1928; in Sweden May 12, 1927.

*Process for producing tarnish-resisting silver and silver plate.* R. O. Bailey and W. S. Murray, assignors to Oneida Community, Ltd. No. 1,773,702. Dec. 14, 1925.

*Centrifugal casting machine.* J. A. and D. S. Gardner. No. 17,783. (Original Patent No. 1,694,504, filed Mar. 4, 1927.) June 21, 1930.

*Refractory furnace wall.* A. F. Hall, assignor to Hall Arch Co. No. 1,773,729. Feb. 6, 1928.

*Molding.* J. F. Hines. No. 1,773,732. Apr. 10, 1925.

*Four-high rolling mill.* O. B. Lindquist, assignor to Allegheny Steel Co. No. 1,773,737. May 25, 1928.

*Process and apparatus for making chain links.* S. D. Locke. No. 1,773,738. Mar. 7, 1923.

*Rotor.* (Die-cast Zn-Al-Cu.) G. W. McCollum, assignor to McCollum Hoist & Mfg. Co. No. 1,773,739. Sept. 16, 1927.

*Method of making projectiles.* G. P. McNiff. No. 1,773,741. Dec. 7, 1925.

*Method and apparatus for manufacture of seamless metallic tubes.* T. H. Nelson. No. 1,773,748. Mar. 13, 1929.

*Method of reducing zinc ore and the product obtained thereby.* E. C. Gaskill, assignor to St. Joseph Lead Co. No. 1,773,779. Dec. 17, 1926.

*Permanent magnet.* (Made of a special steel.) C. Sattler, assignor to the Firm Deutsche Edelstahlwerke Akt.-Ges. No. 1,773,793. Feb. 19, 1930; in Germany Mar. 8, 1929.

*Metal-bending machine.* W. L. Fry, assignor to Wil-Fry Corp. No. 1,773,812. Feb. 8, 1929.

*Pyrometer tube.* F. C. Simms. No. 1,773,825. Nov. 4, 1927.

*Pyrometer tube.* F. C. Simms. No. 1,773,826. July 14, 1928.

*Method and means for forming nut-blank bars.* G. F. Woelfel, assignor to The Commercial Clearing Corp. No. 1,773,836. Aug. 10, 1926.

*Soft-metal disk closure for hard candy, salted peanuts and tobacco cans.* J. F. Peters, assignor to American Can Co. No. 1,773,855. Feb. 19, 1926.

*Machine for forming metal bands.* J. F. Peters, assignor to American Can Co. No. 1,773,856. Jan. 10, 1929.

*Conveyer.* E. L. Smalley, assignor to Hevi Duty Electric Co. No. 1,773,881. June 22, 1928.

*Electric welding.* J. A. Toleik, assignor to American Can Co. No. 1,773,892 Dec. 8, 1926.

*Sintering machine.* C. H. Mace. No. 1,773,916. May 25, 1928.

*Method of manufacturing tubular articles.* W. Merrill. No. 1,773,924 Jan. 30, 1929.

*Tuyère.* R. E. Brakeman. No. 1,773,944. Dec. 23, 1927.

*Process of purifying zinc ore.* O. Gerlach, assignor to Matthiessen & Hegeler Zinc Co. No. 1,773,991. Dec. 31, 1927.

*Apparatus for the manufacture of spiral pipe.* V. Gladkov, assignor to California Corrugated Culvert Co. No. 1,773,994. Nov. 21, 1928.

*Making spiral welded pipe.* A. J. Hand, assignor to California Corrugated Culvert Co. No. 1,774,000. Oct. 18, 1927.

*Arc welding.* J. F. Lincoln, assignor to The Lincoln Electric Co. No. 1,774,023. July 3, 1923.

*Machine for filling molds for founding.* E. O. Beardsley and W. F. Piper, assignors to The Beardsley & Piper Co. No. 1,774,076. Dec. 8, 1924.

*Method of freeing and extracting castings from molds.* L. A. Camerota, assignor to Walter Wood. No. 1,774,082. Sept. 7, 1929.

*Mold and method of filling the same.* R. Minke, assignor to The Vacuum Casting Co. No. 1,774,104. June 13, 1927.

*Sheet-metal-working machine.* L. S. Platou, assignor to The Peck, Stow and Wilcox Co. No. 1,774,155. Nov. 26, 1928.

*Rail Steel.* J. K. Smith, assignor to Granular Iron Co. No. 1,774,189. Nov. 24, 1925.

*Electromagnetically-controlled hydraulic governor for electric and other arc furnaces.* L. Tagliaferri. No. 1,774,213. Dec. 12, 1928; in Germany Dec. 12, 1927.

*Plating process.* B. R. Haueisen, assignor to Metals Protection Corp. No. 1,774,269. May 10, 1929.

*Continuous heating furnace.* F. J. Werner. No. 1,774,306. Mar. 17, 1926.

*Composite product and method of making same.* (Rubber-coated metal.) H. Gray, assignor to The B. F. Goodrich Co. No. 1,774,324. Apr. 22, 1927.

*Blowing slags and the like.* A. Laist, assignor to Anaconda Copper Mining Co. No. 1,774,333. June 11, 1928.

*Process for refining antimonial lead.* T. H. Donahue. No. 1,774,359 Jan. 17, 1929.

*Method of reenforcing welded joints.* W. J. Gamble (deceased). No. 1,774,365. Nov. 8, 1921.
*Mud gun.* J. C. Hopkins and A. Osolin. No. 1,774,373. July 1, 1929.
*Rolling mill.* C. J. Klein, assignor to United Engineering & Foundry Co. No. 1,774,383. Feb. 28, 1929.
*Process of preparing homogeneous alloys of lead.* G. Kränzlein *et al*, assignors to I. G. Farbenindustrie Akt.-Ges. No. 1,774,384. Oct. 24, 1928; in Germany Nov. 5, 1927.
*Metallic tube or shaft.* A. E. Lard, assignor to The Metallic Shaft Co. No. 1,774,385. Oct. 9, 1929.
*Process of producing metallic tubes or shafts.* A. E. Lard, assignor to The Metallic Shaft Co. No. 1,774,386. July 17, 1928.
*Process of precipitating boron.* A. E. Van Arkel, assignor to N. V. Philips Gloeilampenfabrieken. No. 1,774,410. Aug. 18, 1926; in the Netherlands Oct. 5, 1925.
*Chill mold for casting non-iron metals.* A. M. Erichsen. No. 1,774,426. Oct. 24, 1928; in Germany Nov. 2, 1927.
*Water-cooled tuyère.* R. H. Ledbetter. No. 1,774,444. Oct. 14, 1927.
*Converting furnace.* T. M. Kekich, assignor of one-half to C. J. Kekich. No. 1,774,486. Dec. 31, 1927.
*Machine and method for bending metals.* O. Schachtel. No. 1,774,490. Feb. 5, 1923.
*Continuous apparatus working with drawn or blown blast or gas.* A. D. H. L. Fassotte. No. 1,774,135. July 9, 1928; in Belgium July 20, 1927.
*Process of cleaning metal articles.* H. P. Corson and R. E. Lawrence, assignors to The Grasselli Chemical Co. No. 1,773,953. Oct. 9, 1929.
*Utilization of greensand.* W. Vaughan and W. M. Bruce, assignor to The Permutit Co. No. 1,774,533. June 3, 1927.

## British Patents

*Subject of Invention*, Patentee, Patent No. and Filing Date

*Rendering articles of copper or copper alloys resistant to corrosion and oxidation.* J. Laissus. No. 308,353. Mar. 22, 1928.
*Method and apparatus for making dental castings and molds for the same.* F. S. Meyer. No. 322,194. Apr. 9, 1929.
*Die-casting machines.* W. W. Triggs. (A. C. Spark Plug Co.) No. 332,277. Apr. 16, 1929.
*Coreless electrical induction furnaces.* N. R. Davis, *et al.* No. 332,325. May 8, 1929.
*Foundry-molding machines.* G. Zimmermann. No. 332,347. June 4, 1929.
*Rendering utilizable cupriferous and zinciferous ores.* A. L. Mond. (Metallges. Akt.-Ges., and Hochofenwerk Lübeck Akt.-Ges.) No. 318,232. June 26, 1929.
*Manufacture of saline flux coating-compositions for use in soldering or welding.* Alloy Welding Processes, Ltd. No. 314,400. June 26, 1928.
*Electric furnaces.* British Thomson-Houston Co., Ltd. No. 316,562. July 30, 1928.
*Annealing furnaces.* C. F. Kenworthy. No. 332,436. Jan. 14, 1929.
*Electric welding-machines.* British Insulated Cables, Ltd., and L. B. Wilson. No. 332,442. Sept. 3, 1929.
*Sheet metal rolling processes.* American Rolling Mill Co. No. 332,462. Jan. 8, 1929.
*Presses for drawing sheet metal.* C. J. Rhodes. No. 332,492. Nov. 4, 1929.
*Machines for opening sheet-metal bundles.* Etablissements J. J. Carnaud et Forges de Basse-Indre. No. 332,511. Jan. 10, 1929.
*Process and apparatus for the production of tubes upon a pilger rolling-mill.* Mannesmannröhren-Werke. No. 332,513. Feb. 7, 1929.
*Manufacture of articles hardened by nitrogenization.* Molybdenum Corp. of America. No. 315,394. July 13, 1928.
*Process for obtaining rhenium.* Siemens & Halske Akt.-Ges. No. 317,035. Aug. 9, 1928.
*Extraction of rhenium concentrations.* Siemens & Halske Akt.-Ges. No. 332,627. Nov. 22, 1928.
*Degreasing metal articles.* A. K. Croad. (Udylite Ges.). No. 308,363. Mar. 22, 1929.
*Production of tin plate.* Rasselsteiner Eisenwerke-Ges. Akt.-Ges. and H. Främbs. No. 310,061. Apr. 20, 1928.
*Process for the recovery of copper from spent copper lyes.* I. G. Farbenindustrie Akt.-Ges. No. 310,425. Apr. 25, 1928.
*Welding-agent for magnesium alloys.* I. G. Farbenindustrie Akt.-Ges No. 313,487. June 12, 1928.
*Bar-pointing machines.* A. E. Voss. No. 332,644. Apr. 26, 1929.
*Casting of ingots.* C. A. Parsons and H. M. Duncan. No. 332,654. (Addition to 278,032.) May 3, 1929.
*Process of and apparatus for bright-annealing metals.* Metallges.-Akt.-Ges., H. Von Forster, and E. Lay. No. 332,656. May 3, 1929.
*Method of removing gases from molten light metals, such as aluminium and its alloys.* Vereinigte Aluminium-Werke Akt.-Ges. No. 313,489. June 12, 1928.
*Crucible furnaces.* J. W. Penicud. No. 332,701. June 17, 1929.
*Crowns or roofs for furnaces, ovens, and like heating-chambers.* E. Johann. No. 313,886. June 18, 1928.
*Compression of molding-masses for the production of casting molds and cores.* M. Grindal. June 3, 1929. (Patent of Addition not granted.) No. 332,712.
*Electric heaters for rivets and other work pieces.* British Insulated Cables, Ltd., and L. B. Wilson. No. 332,780. Aug. 17, 1929.
*Gas-fired metal-heating furnaces.* Vereinigte Stahlwerke Akt.-Ges. and E. Schreiber. No. 318,552. Sept. 5, 1928.
*Metallurgical furnaces.* W. Alberts. No. 332,850. July 4, 1929.
*Production of scale-free welded tubing.* Air Reduction Co., Inc. No. 332,869. Dec. 10, 1928.
*Process and apparatus for the manufacture of corrugated tubes.* O. Meyer-Keller et Cie. Akt.-Ges. No. 332,870. Jan. 18, 1929.
*Processes for purifying steel.* B. Marks. (Lusifer Products Co.). No. 332,890. Jan. 21, 1929.
*Welding of copper.* W. Andrews and Imperial Chemical Industries, Ltd. No. 332,894. Jan. 29, 1929.
*Molding-machine for producing sand molds.* G. Eckstein. No. 310,548. Apr. 27, 1928.
*Method of and apparatus for melting oxidizable material.* Hirsch, Kupfer-und Messing-Werke Akt.-Ges. No. 313,856. June 16, 1928.
*Method of and means for sectional electroplating, particularly applicable for plating large objects with chromium.* Siemens & Halske Akt.-Ges. No. 314,392. June 26, 1928.
*Machine or apparatus for making up runner bushes employed in casting metals.* J. F. Measures and P. A. Russell. No. 333,024. July 6, 1929.
*Process of making cast iron and steel containing copper.* F. Heusler. No. 317,734. Aug. 20, 1928.
*Rotary-tube furnaces.* T. Lang. No. 319,335. Sept. 20, 1928.
*Water-cooled blowing-tuyères for blast furnaces.* F. D. Brown, G. B. Richards and T. J. Roberts. No. 333,095. Oct. 1, 1929.
*Rotary extruding-presses.* K. Händle, K. Händle & Söhne Maschinenfabrik & Eisengiesserei. No. 333,091. Sept. 26, 1929.
*Automatic control connection for roller beds with electrically driven rollers.* F. Krupp Akt.-Ges. Friedrich-Alfred-Hütte. No. 333,108. Oct. 27, 1928.
*Ferrous alloys.* Browne. No. 302,640. (Amended specification published.)
*Articles made of steel or cast iron and resisting to the attack of corroding-agents and process for producing these articles.* P. F. M., A. J. P. and H. A. M. Duval (trading as Aubert & Duval Fréres). No. 304,783. Feb. 14, 1930.
*Process for heating in a gaseous atmosphere, particularly in a reducing or oxidizing atmosphere.* H. Schaefer. No. 333,192. Feb. 1, 1929.
*Method of or process for rendering austenitic nickel-chromium steels non-corrodible.* W. H. Hatfield and H. Green. No. 333,237. Feb. 5, 1929.
*Reduction of iron ores.* A. Langer. No. 309,998. Apr. 19, 1928.
*Means for producing an intermittent supply of air to blast, smelting and like furnaces.* E. Hickman Y Emparan. No. 311,269. May 8, 1928.
*Heat fuses for use in connection with electric and other furnaces.* Birmingham Electric Furnaces, Ltd., and A. G. Lobley. No. 333,199. Apr. 25, 1929.
*Surface plating of metals with alloys.* Research Corp. No. 310,812. Apr. 30, 1928.
*Electrolytic deposition of gold.* W. F. Grupe. No. 333,246. May 3, 1929.
*Process for the manufacture of articles, particularly screws and rivets, by upsetting in the cold.* Vereinigte Stahlwerke Akt.-Ges. No. 311,337. May 9, 1928.
*Methods of and apparatus for reducing metal stock.* Pipe & Tube Bending Corporation of America. No. 333,281. Apr. 9, 1929.
*Coreless electrical induction furnaces.* N. R. Davis, P. G. Burbridge and Associated Electrical Industries, Ltd. No. 333,254. May 8, 1929.
*Method and means for regulating the electrodes in tilting furnaces.* W. W. Triggs (Flodinjern AB.). No. 333,318. May 21, 1929.
*Cupola furnaces.* J. E. Fletcher and British Cast Iron Research Association No. 333,322. May 24, 1929.
*Pouring ladles.* W. T. Collyer. No. 333,384. Aug. 1, 1929.
*Foundry cores.* A. Stahn. No. 333,385. Apr. 16, 1929.

## Canadian Patents

*Subject of Invention*, Patentee, Patent No. and Filing Date

*Tape solder.* R. B. Campbell. No. 302,677. Dec. 20, 1927.
*Hardness testing method and hardening of metals.* E. G. Herbert. No. 302,702. Aug. 20, 1928.
*Universal torch machine.* The Air Reduction Co., Inc., assignee of E. L. Ragonnet. No. 302,748. Dec. 9, 1929.
*Process of rolling sheets.* The American Rolling Mill Co., assignee of W. Stringham. No. 302,756. June 21, 1929.
*Blast furnace bell.* H. A. Brassert & Co., assignee of P. Zimmermann. No. 302,765. Nov. 6, 1929.
*Process of treating ores of titanium containing chromium and of recovering the sulphuric acid.* Deutsche Gasglühlicht-Auer-Ges., assignee of N. Specht. No. 302,793. Apr. 10, 1929.
*Preparation for cleaning metal preparatory to painting.* J. D. Klinger and C. L. Boyle. No. 302,890. Mar. 15, 1928.
*Wet extraction of copper.* F. Dietzsch. No. 302,905. July 23, 1928.
*Method of making electron-emitting material (W-Mo-Th).* The Canadian Westinghouse Co., Ltd., assignee of W. B. Gero. No. 302,979. Apr. 16, 1927.
*Production of ductile chromium.* The Canadian Westinghouse Co., Ltd, assignee of J. W. Marden and M. N. Rich. No. 302,980. Apr. 29, 1927.
*Resistance element (made of chromium).* The Canadian Westinghouse Co., Ltd., assignee of J. W. Marden. No. 302,981. Sept. 9, 1927.
*Apparatus for working metal.* The Pipe & Tube Bending Corp. of America, assignee of J. E. Neuberth. No. 303,036. May 6, 1929.
*Apparatus for casting metals.* The American Metal Co., Ltd., assignee of W. F. Eppenstein and H. M. Green. No. 303,050. Mar. 21, 1929.
*Method of producing magnetic materials.* (Brittle ferromagnetic alloys.) The Western Electric Co., Inc., assignee of J. W. Andrews. No. 303,055. Jan. 6, 1928.
*Soldering device.* D. H. Bottrill. No. 303,081. May 2, 1929.
*Electric furnace.* C. E. Cornelius. No. 303,089. Jan. 5, 1929.
*Reduction of metal ores capable of volatilization.* F. L. Duffield. No. 303,095. July 3, 1929.
*Cast iron.* The British Cast Iron Research Assoc., assignee of A. L. Norbury and E. Morgan. No. 303,180. Oct. 3, 1929.
*Method of purifying magnesium.* I. G. Farbenindustrie A.G., assignee of W. Schmidt and A. Beck. No. 303,204. Feb. 27, 1929.
*Process of making tungsten alloys.* The Mills Alloys, Inc., assignee of O. L. Mills. No. 303,226. Nov. 14, 1929.
*Method of electrolysis (prevention of sprdy or fog liberation).* U. C. Tainton. No. 303,359. May 13, 1929.
*Electrolytic precipitation of metals.* U. C. Tainton. No. 303,360. Nov. 13, 1929.
*Bending machine for rods and profile irons.* A. Wagenbach. No. 303,367. May 5, 1928.
*Process of carbonizing nickel.* The Canadian Westinghouse Co., Ltd., assignee of H. M. Elsey. No. 303,407. May 20, 1929.
*Technically pure $CrO_3$.* The Metals Protection Corp., assignee of C. H. Humphries. No. 303,455. Nov. 12, 1929.
*Process of recovering selenium.* The United States Metals Refining Co., assignee of D. L. Ogden and R. E. Valentine. No. 303,480. Oct. 31, 1929.

## Danish Patents

*Subject of Invention*, Patentee, Patent No. and Filing Date.

*Process for the production of a protective coating of lead peroxide on electric conductors.* Siemens & Halske A.G. No. 42,524. Oct. 9, 1928.
*Austenitic chromium-nickel steel.* Fried. Krupp A.G. No. 42,527. Jan. 18, 1929.
*Process for making transformer sheets and the like.* N. V. Philips' Gloeilampenfabrieken. No. 42,540. June 6, 1928.
*Process for making molded pieces for tools of difficultly workable substances, such as carbides, alloys of these and the like.* Fried. Krupp A.G. No. 42,570. June 10, 1929.

*Process for refining and mixing metals and alloys.* T. D. Kelly and G. E. Leavey. No. 42,604. Feb. 6, 1929.

## French Patents

*Subject of Invention*, Patentee, Patent No. and Filing Date.

*Continuous furnace for the heat treatment of metals and other substances.* Ugine Infra. No. 691,120. May 8, 1929.

*Method of prolonging the life of blast furnace shafts.* S. A. John Cockerill No. 691,221. Mar. 5, 1930.

*Production of finely divided metals from their carbonyl compounds.* I. G. Farbenindustrie A.G. No. 691,243. Mar. 6, 1930.

*Improvements in the production of aluminum by electrolysis.* Cie. des Produits Chimiques & Electrométallurgiques Alais, Froges & Camargue. No. 691,336. May 21, 1929.

*Brake at entrance end of mill for cold-rolling strip metal.* W. Bauer. No. 691,382. Feb. 12, 1930.

*Improvements to hard metal compositions and to processes for making them.* Cie. Française pour l'Exploitation des Procédés Thomson-Houston. Addition No. 37,167. (Second addition to No. 654,210 filed Apr. 4, 1928.) July 1, 1929.

*Improvements to machines for extruding tubing.* E. Begot. No. 691,156. May 13, 1929.

*Improvements to stationary arc-welding machines using three-phase current.* La Soudure Autogéne Francaise. No. 691,163. May 14, 1929.

*Process for casting metals and mold facings used in this process.* Syndicat pour l'Exploitation de Brevets de Fonderies Mayer & Co. (Sebma), S.A. No. 691,235. Mar. 6, 1930.

*Metals or compositions for welding.* I. G. Farbenindustrie A.G. No. 691,-242. Mar. 6, 1930.

*Electric welding.* Westinghouse Electric and Manufacturing Co. No. 691,249. Mar. 6, 1930.

*Process and machine for making welded tubing, particularly precision tubing,* J. Kozicz. No. 691,369. Jan. 30, 1930.

*Improvements in the manufacture of strip material and the like.* The Cold Metal Process Co. No. 691,404. Mar. 6, 1930.

*Aluminum solder.* W. Reuss. Addition No. 37,159. (Second addition to No. 645,549 filed Dec. 10, 1927.) June 28, 1930.

*Electrolytic process for obtaining substances and metallic compounds having a low coefficient of solubility in the electrolyte.* N. R. Romulo. No. 691,-378. Feb. 10, 1930.

## German Patents

*Subject of Invention*, Patentee, Patent No. and Filing Date.

*Cleaning and degreasing apparatus.* A. Wacker Ges. für elektrochemische Industrie G.m.b.H. No. 504,910. Jan. 30, 1927.

*Process for coating with cadmium in a molten bath.* L. Rostosky and E. Lüder. No. 504,888. Oct. 18, 1928.

*Process for producing a primary manganophosphate which is suitable for preparing a rust-proofing bath.* N.V.Mij. tot Exploitatie van de Parker Octrooien "Parker Rust Proof." No. 504,568. Apr. 5, 1927; in the United States May 10, 1926.

*Process for making laminated sheet metal of a plurality of metals.* Fried. Krupp A.G. No. 504,725. Nov. 12, 1926.

*Process for working up low-grade siliceous iron ores.* Maschinenbau-Anstal-Humboldt. No. 505,097. Aug. 31, 1924.

*Reducing rolling mill.* Vereinigte Stahlwerke A.G. No. 505,303. Mar. 3, 1927.

*Skew rolling mill for making tubing.* Maschinenfabrik Sack G.m.b.H., and J. Gassen. No. 505,250. (Addition to No. 418,002.) Jan. 16, 1924.

*Device for automatically controlling the rolling process in strip mills.* Remy van der Zypen & Co., and E. G. Köhler. No. 505,155. Nov. 22, 1927.

*Roller conveyor for cooling beds having several adjacent runways for the rolled material.* F. Skalsky. No. 505,059. Dec. 1, 1929; in Czechoslovakia Dec. 5, 1928.

*Device for lifting the rolled bars out of the runway of a hot bed.* Demag A.G. No. 505,060. May 8, 1929.

*Manipulator for rolling mills.* J. Banning A.G. and R. Feldmann. No. 505,195. July 19, 1928.

*Method of controlling the speed of moving bars, combined with a device for separating and arranging.* Maschinenfabrik Sack G.m.b.H. No. 505,-061. July 23, 1927.

*Process for making cobalt carbonyl.* I. G. Farbenindustrie A.G. No. 505,-211. (Addition to No. 448,036.) Aug. 13, 1926.

*Current lead-in device for the electrodes of electric furnaces.* Det Norske A/S. for Elektrokemisk Industri. No. 505,169. Sept. 10, 1926; in Norway Sept. 19, 1925.

*Compressed-air jolter for molding machines.* A.G. der Eisen- & Stahlwerke vormals Georg Fischer. No. 505,333. May 26, 1929.

*Machine for casting pig iron under pressure.* F. Stuhl. No. 505,224. Feb. 16, 1930; in France Nov. 18, 1929.

*Closure for the tap holes of melting furnaces or pouring devices.* M. Drechsler No. 505,225. Jan. 30, 1930.

*Decomposition of cobalt ores.* Gebr. Borchers A.G. and F. Borchers. No. 505,229. Jan. 24, 1929.

*Alloy for making metal foil.* American Machine & Foundry Co. No. 505,-173. May 31, 1928.

*Rolling mill with corrugated rolls.* Eisen- und Stahlwerk Hoesch A.G. No. 505,468. July 6, 1928.

*Feeding and braking device for pilger rolling mills.* E. Röber. No. 505,609. Mar. 15, 1928.

*Arrangement of backing rolls of rolling mills with five or six rolls.* No. 505,559. June 1, 1928.

*Individual electric drive for the rolls of roller beds for rolling mills.* Maschinen fabrik Sack G.m.b.H. No. 505,469. (Addition to No. 486,162.) Jan. 26, 1928.

*Method of mounting heating resistances in electric furnaces.* Hirsch, Kupfer- und Messingwerke A.G. No. 505,384. Oct. 19, 1927.

*Electric furnace.* Siemens-Schuckertwerke A.G. No. 505,385. July 31, 1926.

*Apparatus for firing crucibles, etc.* Statlaiche Porzellan-Manufaktur. No. 505,386. (Addition to No. 492,342.) Aug. 12, 1926.

*Packing piece for the electrodes of arc furnaces.* Allgemeine Elektrizitäts Gesellschaft. No. 505,387. Apr. 27, 1926.

*Pressure-molding process and machine for making molds for pipes, pipe connections and other castings.* No. 505,526. Nov. 23, 1928.

*Water-cooled chill mold made of thin sheet metal for casting plates for rolling.* Hirsch, Kuper- und Messingwerke A.G. No. 505,511. Dec. 22, 1927.

*Method and device for extracting hollow patterns or castings from sand molds* C. B. Pike. No. 505,576. Dec. 28, 1928.

*Air-cooled rabbling mechanism.* Balz-Erzröstung G.m.b.H. No. 505,581. (Addition to No. 485,618.) Apr. 18, 1929.

*Production of cadmium.* Metallgesellschaft A.G. No. 505,582. June 19, 1929.

*Air circulation for mechanical roasting furnaces with air-cooled rabbling mechanism.* Balz-Erzröstung G.m.b.H. No. 505,583. Nov. 24, 1927.

*Working up manganese-bearing ores, tailings, slimes or muds.* K. E. Dittmann and K. Faerber. No. 505,584. Jan. 20, 1928.

*Process for producing a metallic coating on all kinds of objects.* H. Mayr. No. 505,508. Aug. 4, 1928.

*Process for making seamless tubing in the Ehrhardt press.* Heraeus-Vacuumschmelze A.G. No. 505,542. Aug. 18, 1928.

*Last-stage and coiling drum with vertical axis, for multiple wiredrawing machines.* W. Nacken. No. 506,033. Feb. 22, 1929.

*Device for stripping bundles of strip or wire from a coiling wheel having a horizontal axis.* Demag A.G. No. 505,787. Aug. 12, 1928.

*Pit beneath a vertical extrusion press.* Hydraulik G.m.b.H. and O. Schlenstedt. No. 505,671. Nov. 9, 1927.

*Method of partial removal of remaining material from lead cable presses.* Fried. Krupp Grusonwerk A.G. No. 506,034. Aug. 7, 1929.

*Device for guiding the mandrel of tubing presses.* Demag A.G. No. 506,035. Sept. 13, 1929.

*Process for making flexible tubular shafting.* Clifford Manufacturing Co. No. 506,036. Oct. 27, 1928.

*Rotary tubular furnace.* E. F. Russ. No. 505,901. Mar. 20, 1925.

*Device for opening and closing the doors of annealing or muffle furnaces.* A. G. Lobley and Birmingham Electric Furnace, Ltd. No. 505,691. Jan. 11, 1929; in Great Britain Jan. 11, 1928.

*Process for oxidizing plates for copper-oxide rectifiers.* Siemens-Schuckertwerke A.G. No. 505,811. Oct. 25, 1927.

*Process for producing a metallic coating on the oxide layer of a metal-oxide rectifier.* Siemens-Schuckertwerke A.G. No. 505,812. Jan. 8, 1929.

*Process for making electrodes.* B. Redlich. No. 505,813. (Addition to No. 447,678.) July 31, 1929.

*Bearing with guides for the core used in casting.* F. Kertész. No. 505,781. Apr. 15, 1928.

*Air-tight closure for the discharge opening of shaft roasting furnaces.* Vereinigte Stahlwerke A.G. No. 505,962. Nov. 28, 1929.

*Rotary drum furnace for roasting sulphidic ores and the like.* Metallgesellschaft A.G. No. 505,863. Feb. 5, 1927.

*Recovery of copper from residual liquors.* I. G. Farbenindustrie A.G. No. 505,826. Apr. 26, 1928.

*Furnace for the production of pure tin directly from tin ores or concentrates thereof.* Cayzer Tin Smelting Co. (Pty), Ltd. No. 505,722. June 17, 1928.

*Bronze metal.* G. Stratenwerth. No. 505,963. Apr. 21, 1928.

*Process for making thorium alloys.* Kemet Laboratories Co., Inc. No. 505,964. Dec. 23, 1926.

*Process for the separation of refined aluminum from its alloys.* R. Müller. No. 505,965. Dec. 1, 1928.

*Electrolytically produced block of metal and process for making the same.* Soc "Le Nickel." No. 505,966. July 1, 1927; in France Apr. 13, 1927.

*Electrolytic apparatus for the separation of tin from tin-bearing solutions.* L. U. La Corsa. No. 505,967. Dec. 28, 1928; in Italy June 9, 1928.

*Apparatus for the electrolytic production of alloys.* E. Kelsen. No. 505,968 Aug. 17, 1928; in Austria Aug. 24, 1927.

*Process and apparatus for electroplating hollow bodies.* Metallwarenfabrik Johann Jäckle G.m.b.H. No. 505,979. Feb. 20, 1929.

*Device for hanging articles to be chromium plated on a bus bar constructed as an exhaust duct for the fog from the bath.* W. A. F. Pfanhauser. No. 505,-864. Aug. 20, 1926.

*Cleaning and degreasing agent for objects made of solid material, using solvents having high specific gravity in the vapor state.* Dr. Alexander Wacker Ges. für elektrochemische Industrie G.m.b.H. No. 505,980. July 19, 1927.

*Process for making iron zincing pots.* O. Middermann. No. 505,678. Dec. 13, 1928.

*Method of detecting porous spots and the like in protective coatings on iron objects.* E. Vopel. No. 505,728. July 17, 1927.

*Process for improving aluminum sheets and strips, particularly for the fabrication of kitchen utensils.* Vereinigte Silberhammerwerke Hetzel & Co. No. 505,733. June 2, 1928.

*Tubing extrusion press.* Hydraulik G.m.b.H. No. 506,123. Sept. 16, 1926.

*Process for preparing ingots for the extrusion press.* A. Kreuser G.m.b.H. No. 506,138. July 10, 1928.

*Process for melting pulverulent masses.* A. Dawans. No. 506,350. Aug. 5, 1927.

*Furnace installation for reducing metallic oxides, particularly iron oxides, with production of solid unmelted metal.* Granular Iron Co. No. 506,340; in the United States Sept. 8, 1926.

*Process for producing titanium-free iron or steel.* Mrs. F. A. De Silva and C. G. Carlisle. No. 506,351. July 1, 1927; in Great Britain May 18, 1927.

*Process for making a foundry product containing iron-oxygen compounds.* R. Schenck. No. 506,352. Sept. 24, 1927.

*Coal-dust-fired regenerative heating and melting furnace.* F. Siemens A.G. No. 506,353. Mar. 2, 1927.

*End wall of an open-hearth furnace.* Vereinigte Stahlwerke A.G. No. 506,-354. Sept. 28, 1928.

*Method of operating regenerative hearth furnaces.* Witkowitzer Bergbau-und Eisenhütten-Gewerkschaft, and C. Salat. No. 506,341. (Addition to No. 500,792.) Feb. 26, 1927.

*Process for making a coherent electrically conductive metallic layer on crystals.* Hanovia Chemical & Manufacturing Co. No. 506,570. Dec. 18, 1927.

*Process for making plates for copper-oxide rectifiers.* Siemens-Schuckertwerke A.G. No. 506,071. Nov. 27, 1927.

*Means for reducing the surface of the oxide layer of metallic-oxide rectifier plates.* Siemens-Schuckertwerke A.G. No. 506,374. Nov. 26, 1929; in the United States Dec. 7, 1928.

*Process for forming metallic coatings on elements made of non-conducting oxides for indirectly heated cathodes of electric discharge tubes.* Allgemeine Elektricitäts Gesellschaft. No. 506,459. Apr. 2, 1926.

*Method of operating an electric melting furnace.* Demag A.G. No. 506,303. Dec. 20, 1928.

*Device for moving the electrodes of electric furnaces.* J. Schlösser. No. 506,-304. (Addition to No. 473,144.) Aug. 9, 1929.

*Current lead-in for electrodes.* Vereinigte Aluminium-Werke A.G. No. 506,305. June 29, 1928.

*Process for making iron rolls by casting around a highly heated metal core.* Gewerkschaft Kronprinz. No. 506,194. Feb. 24, 1929.

*Production of zinc from zinc-poor liquors from the leaching of chloridizing-roasted ores.* Metallgesellschaft A.G. No. 506,343. Dec. 14, 1926.

*Bearing metal.* N. V. Tinkoper Handel-Mij. No. 506,082. Nov. 11, 1926.
*Process for making sheet iron galvanizing pots.* O. Middermann. No. 506,-131. Apr. 19, 1928.

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*Subject of Invention*, Patentee, Patent No. and Filing Date

*Electric furnace with double hearth for melting metals and treating ores.* F. Bassanese. No. 267,593. Mar. 8, 1928.
*Improvements to processes for roasting and sintering fine ores and other fine materials.* Cie. des Metaux Overpelt-Lommel S.A. No. 267,691. Feb. 13, 1928.
*Improvements to process for roasting and reducing metallic ores and treating other materials.* F. L. Duffield. No. 267,977. Mar. 30, 1928.
*Improved manufacture of alloys of copper, nickel and aluminum.* International Nickel Co., Inc. No. 268,029. Mar. 20, 1929; in Great Britain Mar. 4, 1926 (British Patent No. 250,194).
*Process for plating aluminum and aluminum alloys.* B. Jirotka. No. 267,-594. Mar. 8, 1928; in Germany Mar. 10, 1927.
*Improvements in the treatment of iron pyrites.* I. S. Levy and G. W. Gray. Nos. 267,745 and 267,746. Mar. 8, 1928.
*Fire-resistant alloy of iron, nickel. chromium, silicon and carbon.* Meier & Weichelt. No. 267,932. Mar. 26, 1928; in Germany Mar. 28, 1927.
*Alloys of copper suitable for rolling, stamping, drawing, etc., and having great strength, hardness and toughness.* Metallbank und Metallurgische Ges. A.G. No. 267,475. Mar. 2, 1928; in Germany Mar. 5, 1927.
*Improvements to alloys of copper and silicon.* Same patentee. No. 267,857. Mar. 8, 1928.
*Process for rending utilizable ores containing copper and zinc.* Same patentee. No. 267,916. Mar. 14, 1928; in Germany Apr. 7, 1927.
*Aluminum alloy having three or more components.* Same patentee. No. 267,999. Mar. 17, 1928; in Germany Dec. 18, 1927 (German Patent No. 456,343.)
*Process for producing gold and silver.* V. Volpato. No. 268,022. Feb. 14, 1928.
*Feed for the rollers of electric welders.* G. T. M. Brotto. No. 267,346. Feb. 29, 1928.
*Improvements to machines for rolling metal tires.* Budd Wheel Co. No. 267,721. Mar. 14, 1928; in the United States Mar. 19, 1927.
*Process for treating bodies having a crystalline structure, particularly metals, for the purpose of controlling this structure by annealing, tempering and the like.* S. Junghans. No. 267,392. Feb. 10, 1928.
*Process for rendering possible the use of metal cores in the production of castings.* S. Junghans. No. 267,579. Mar. 9, 1928; in Germany Mar. 29, 1927, in the name of Messingwerk Schwarzwald A.G.
*Method of removing burrs from castings.* S. Junghans. No. 267,601. Mar. 9, 1928; in Germany Mar. 29, 1927, in the name of Messingwerk Schwarzwald A.G.
*Nozzle for sand-projecting machines.* Ruhr-Maschinenvertrieb Dipl. Ing. Jacobovic & Nassau. No. 268,023. Feb. 23, 1928; in Germany Feb. 24, 1927.
*Process for rolling tubing from a hollow billet and machines for working this process.* M. Roeckner. No. 267,912. Jan. 25, 1928; in Germany Feb. 25, 1927.
*Process for forming coatings on metals.* Dr. Otto Sprenger Patentverwertung Jirotka m.b.H. No. 267,591. Feb. 27, 1928.
*Process for providing wire, sheet, or strip of aluminum or aluminum alloys with an insulating, elastic, adherent coating.* Spezialfabrik für Aluminium Spulen und Leitungen G.m.b.H. No. 267,865. Mar. 22, 1928; in Germany Mar. 22, 1927.
*Process for making welded pressure vessels.* C. Wallmann and F. Nehl. No. 267,391. Dec. 14, 1927; in Germany Feb. 17, 1927.
*Induction furnace.* E. F. Russ. No. 267,633. Mar. 9, 1928.
*Improvements to electric furnaces.* Soc. Electrométallurgique de Montricher. No. 267,308. (First addition to No. 263,302, filed Dec. 17, 1927.) Dec. 19, 1927; in France Oct. 13, 1927.
*Device for cutting moving metal bars.* Soc. d'Etudes et de Constructions. Métallurgique, and A. Grosbost. No. 268,011. Mar. 19, 1928; in France Mar. 19, 1927.
*Process for hardening the surface of cast iron.* Aubert & Duval Frères. No. 268,126. Mar. 10, 1928; in Germany Mar. 17, 1927, in the name of Fried. Krupp A.G.
*Metallurgical electric induction furnace.* G. Beccalossi. No. 268,113. Mar. 23, 1928.
*Metallurgical coal and process for producing the same.* La Carbonisation, Soc. Gen. d'Exploitation des Carbones. No. 268,506. Apr. 10, 1928; in France Apr. 11, 1927, in the names of G. De Korff and G. Jakova-Merturi. (French Patent No. 632,623.)
*Method and procedure for producing a very hard composite metal.* Cia. Gen. di Elettricita. No. 268,378. Apr. 6, 1928; in the United States Apr. 6, 1927, in the name of S. L. Hoyt.
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*Process for decarburizing ferro-alloys.* Electro Metallurgical Co. No. 268,-470. Apr. 11, 1928.
*Process for producing metallic carbonyls.* I. G. Farbenindustrie A.G. No. 268,765. May 4, 1928; in Germany May 4, 1927.
*Process for producing cement and iron.* C. B. Hillhouse. No. 268,366. Apr. 14, 1928.
*Improvements to alloys, especially those for kitchen utensils.* International Nickel Co., Inc. No. 268,275. Mar. 23, 1928.
*Process for recovering tin from tinplate or any objects made of metal containing tin.* Q. Marino. No. 268,420. Apr. 18, 1928; in France Dec. 27, 1926. (French Patent No. 626,777.)
*Heat-resistant iron-chromium-nickel alloy.* Oesterreichische Schmidstahlwerke A.G. No. 268,707. Apr. 24, 1928; in Austria Apr. 25, 1927, in the name of L. Klüger.
*Method of improving iron-beryllium alloys.* Siemens & Halske A.G. No. 268,597. Apr. 6, 1928; in Germany Apr. 12, 1927.
*Process for treating ores, residues and the like for the purpose of extracting the metals contained therein.* S. C. Smith. No. 268,667. Apr. 3, 1928; in Great Britain Apr. 5, 1927.
*Casting mold combined with means for extracting cores.* Bohn Aluminum and Brass Corp. No. 268,114. Apr. 5, 1928.
*Improvements to processes for making finned tubing.* H. W. Bundy. No. 268,618. Apr. 24, 1927; in the United States Apr. 27, 1927.
*Improved process for protecting metallic objects against corrosion and materials for use in working the same.* H. Cole. No. 268,088. Mar. 19, 1928; in Great Britain Mar. 19, 1927.
*Process for forming colored or colorless, adherent coatings on metal, wood, etc.* I. G. Farbenindustrie A.G. No. 268,878. May 25, 1928.
*Method and machine for bending metal.* E. Fagliati. No. 268,289. Mar. 22, 1928.
*Process for die-casting metals having a high melting point.* P. Haessler. No. 268,390. Apr. 10, 1928; in Germany Oct. 21, 1927.
*Process for inhibiting corrosion of metals by means of halogenated hydrocarbons.* W. Kinberg. No. 268,475. Apr. 30, 1928; in Germany Feb. 11, 1928.
*Improvement in the joining of metallic tubing by welding.* M. Longhi. No. 268,252. Apr. 3, 1928.
*Process for making cores for casting cylinders, pipes, etc.* G. Marengo. No 268,671. Apr. 3, 1928.
*Process for rendering sheet, strip, wire and the like of impure aluminum or aluminum alloys resistant to chemical action and to atmospheric agencies.* Metallbank und Metallgurische Ges. A.G. No. 268,580. Mar. 30, 1928; in Germany Apr. 3, 1924. (German Patent No. 429,948.)
*Process for rolling thin strip iron.* C. Rötzel. No. 268,697. Apr. 28, 1928; in Germany May 5, 1927.
*Method and device for effecting uniform circulation of the electrolyte in electrolytic cells for the electrolytic production of metals.* I. G. Farbenindustrie A.G. No. 268,165. Feb. 21, 1928; in Germany Feb. 21, 1927.
*Electrolytic process for the production of zinc.* I. G. Farbenindustrie A.G. No. 268,268. Feb. 7, 1928; in Germany Feb. 14, 1927.
*Improvements in the electrolytic production of light metals.* L. P. Hulin. No. 268,216. Feb. 2, 1928; in France Feb. 3, 1927.
*Process for rendering the surface of wax and the like electrically conducting, for the purpose of making matrices for phonograph records.* Gramophone Co., Ltd. No. 268,087. Feb. 28, 1928; in Great Britain Mar. 21, 1927, in the name of B. Ugo.
*Method of heating with three-phase arcs.* O. Scarpa. No. 268,594. May 8, 1928.

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*Subject of Invention*, Patentee, Patent No. and Filing Date

*Cooling system for bright-annealing furnaces.* Siemens-Schuckertwerke A.G. No. 48,387. Nov. 6, 1928.
*Process and apparatus for roasting and reducing ores.* F. L. Duffield. No. 48,416. Mar. 28, 1928.

## Swedish Patents

*Subject of Invention*, Patentee, Patent No. and Filing Date

*Roll bearing for universal rolling mills.* H. Stüting. No. 69,982. May 5, 1928.
*Method of making lead-in wires for electric lamps.* Metal & Thermit Corp. No. 69,996. Mar. 6, 1926. Priority date Mar. 10, 1925.
*Charging-car for sintering apparatus.* J. E. Greenawalt. No. 70,004. Dec. 27, 1929.
*Process for coating iron objects with zinc or zinc alloys.* T. Liban. No. 70,010. Sept. 8, 1926.
*Process for making tools of very hard homogeneous alloys.* Fried. Krupp A.G. No. 70,012. July 29, 1929.
*Process for making copper-bearing iron and steel.* F. Heusler. No. 70,037. Aug. 20, 1929. Priority date Aug. 20, 1928.
*Centrifugal casting machine.* Beatty, Palmer & Beatty. No. 70,050. Dec. 7, 1928.
*Method of working up sulphidic ores and metallurgical products.* F. Krupp Grusonwerk A.G. No. 70,053. (Addition to No. 67,195.) May 31, 1927. Priority date July 11, 1926.
*Process for forming a corrosion-proof layer on aluminum or aluminum alloy objects.* Platen-Munters Refrigerating System AB. No. 70,057. June 16, 1928. Priority date June 18, 1927.
*Process and machine for centrifugal casting.* R. B. Dale. No. 70,224. Sept. 18, 1926. Priority date Dec. 23, 1925.
*Method of altering the form of sheet metal.* H. Junkers. No. 70,225. Oct. 31, 1929. Priority date Dec. 18, 1928.
*Process for the rapid rolling of sheet and strip iron.* Eisen u. Stahlwerk Hoesch A.G. No. 70,297. Priority date May 1, 1928.
*Process for making hollow metal bars by rolling.* AB. Svenska Kullagerfabriken Hofors Bruk. No. 70,298. June 28, 1929.

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*Subject of Invention*, Patentee, Patent No. and Filing Date.

*Process for making a rust-proofing bath.* Soc. Continentale Parker. No. 139,197. Oct. 12, 1926; in the United States Jan. 25, 1926.
*System of making casting molds.* G. Eckstein. No. 139,237. Apr. 25, 1929; in Germany Apr. 27, 1928.
*Apparatus for the autogenous cutting of holes.* H. Greggersen. No. 139,238. Mar. 18, 1929; in Germany June 5, 1928.
*Process for forming coatings on metal or wood.* I. G. Farbenindustrie A.G. No. 139,250. Dec. 8, 1928.
*Furnace for annealing bar stock.* Siemens-Schuckertwerke A.G. No. 139,-314. June 24, 1929.
*Electric furnace for annealing metals.* Siemens Schuckertwerke A.G. No. 139,315. July 3, 1929; in Germany Mar. 20, 1929.
*Highly refractory body and process for making the same.* T. R. Haglund. No. 139,462. Feb. 23, 1928; in Germany June 4, Sept. 27, and Nov. 25, 1927.
*Process for the superficial metallization of non-metallic objects.* G. L. Dazelle. No. 139,518. Feb. 7, 1929.
*Process for increasing the ductility, flexibility and rollability of aluminum alloy sheet, strip, wire, etc.* Aluminium Industrie A.G. No. 139,519. May 23, 1929; in Germany Oct. 12, 1928.
*Process for making an iron alloy.* T. R. Haglund. No. 139,549. Feb. 6, 1928; in Sweden Feb. 9, 1927.
*Process for making cast iron from wrought iron or steel scrap.* Svenska AB. Gasaccumulator. No. 139,950. June 26, 1929; in Sweden June 30, July 28 and Sept. 28, 1928.
*Process for improving magnesium alloys.* I. G. Farbenindustrie A.G. No. 139,551. July 8, 1926.
*Process for making shaped objects for tools out of difficultly workable alloys, such as carbides, their alloys, and the like.* Fried. Krupp A.G. No. 139,552. June 10, 1929; in Germany June 15, 1928.
*Process for making aluminum-silicon alloys containing over 60% aluminum.* Aluminium Industrie A.G. No. 139,553. Nov. 23, 1928.
*Compressed-air vibrator for molding machines.* A.G. der Eisen u. Stahlwerk vormals Georg Fischer. No. 139,554. May 26, 1929.
*Flux-coated electrodes for electric welding.* J. Mehl. No. 139,555. Apr. 10, 1929; in Germany Apr. 23, 1928.
*Method of bright annealing metal sheets in annealing pots.* A.G. Brown, Boveri & Cie. No. 139,556. July 2, 1929; in Germany July 7, 1928.